US008941315B2

(12) **United States Patent**
Jmaev

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(45) **Date of Patent: Jan. 27, 2015**

(54) **METHOD AND APPARATUS FOR SYNCHRONOUS SINE WAVE DIMMING OF LUMINARIES**

(76) Inventor: **Jack Ivan Jmaev**, Chino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/261,575**

(22) PCT Filed: **Jul. 26, 2011**

(86) PCT No.: **PCT/US2011/001338**
§ 371 (c)(1),
(2), (4) Date: **Jan. 26, 2013**

(87) PCT Pub. No.: **WO2012/018376**
PCT Pub. Date: **Feb. 9, 2012**

(65) **Prior Publication Data**
US 2013/0181634 A1 Jul. 18, 2013

Related U.S. Application Data

(60) Provisional application No. 61/400,440, filed on Jul. 27, 2010, provisional application No. 61/456,304, filed on Nov. 3, 2010.

(51) **Int. Cl.**
H05B 37/02 (2006.01)
G05F 1/24 (2006.01)
H05B 41/38 (2006.01)

(52) **U.S. Cl.**
CPC ***G05F 1/24*** (2013.01); ***H05B 41/38*** (2013.01); ***H05B 37/02*** (2013.01)
USPC **315/226**; 315/247; 315/287; 315/308; 315/360; 323/207

(58) **Field of Classification Search**
CPC H05B 37/02; H05B 39/02; H05B 39/04; H05B 41/14; H05B 41/36
USPC .... 315/209 R, 226, 247, 283, 287, 291, 315/308, 360; 323/206, 207, 220; 388/907, 388/921
See application file for complete search history.

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8,283,901 B2 * 10/2012 Lopata et al. 323/224

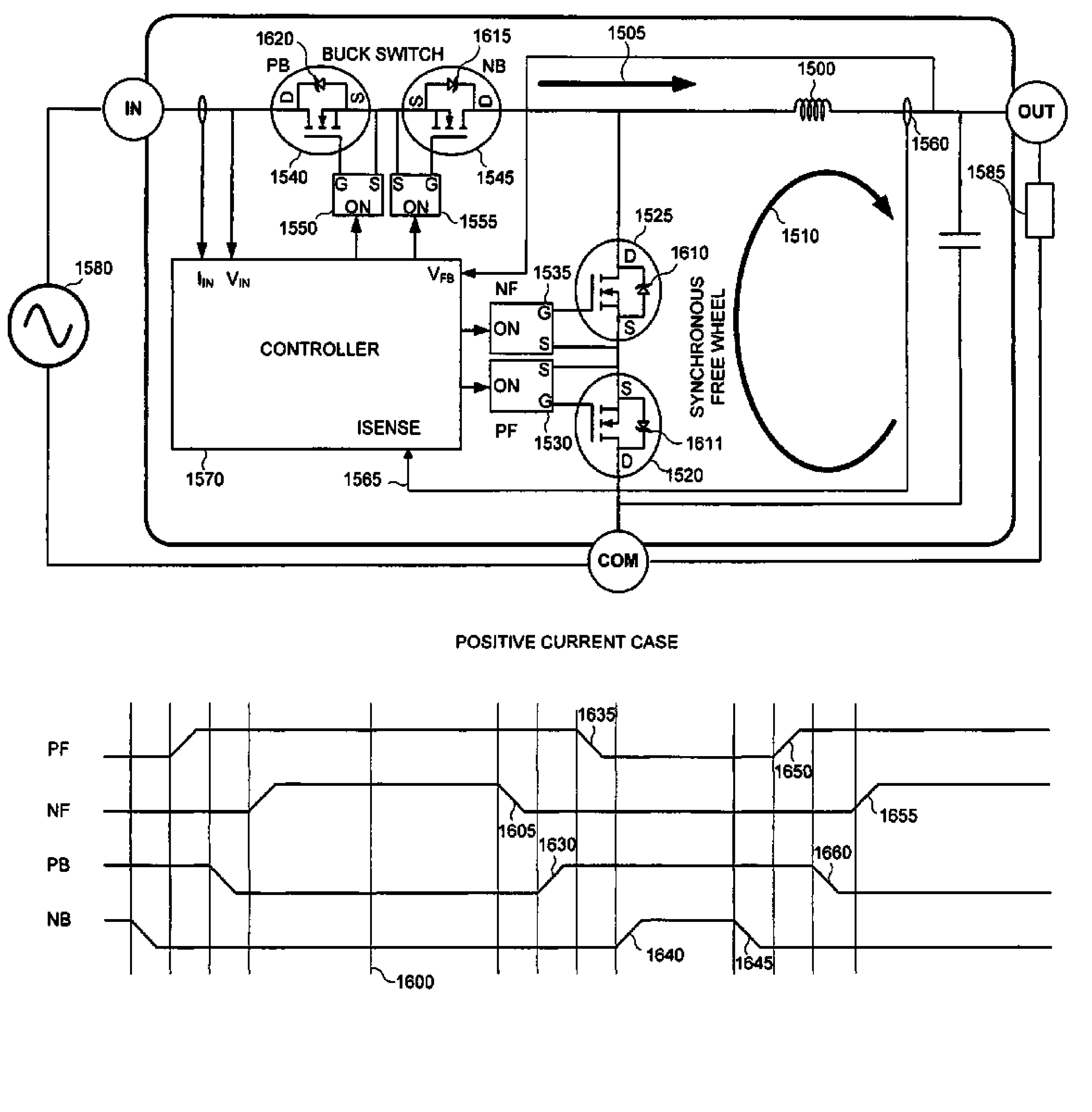
* cited by examiner

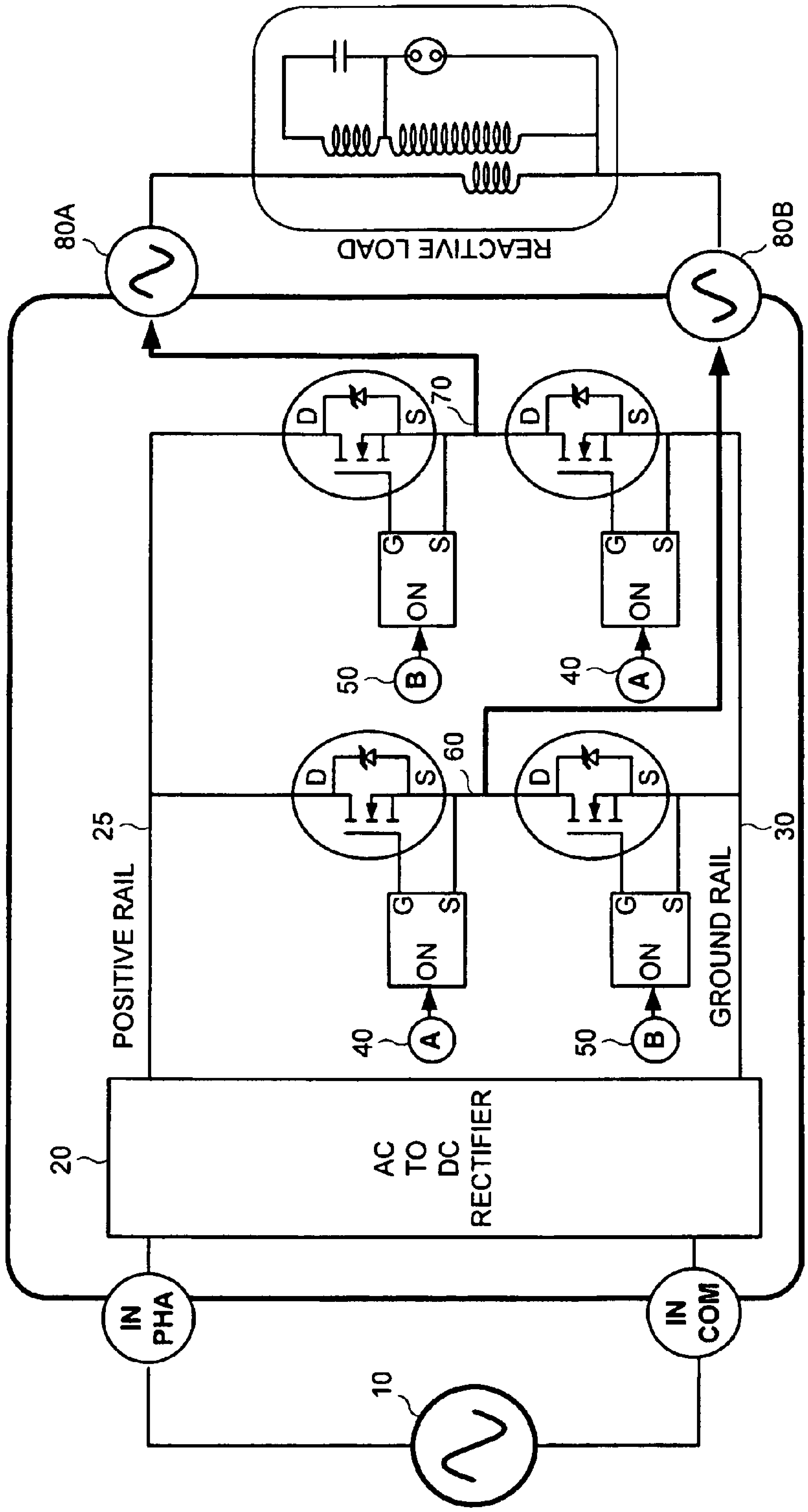
Primary Examiner — Thuy Vinh Tran
(74) *Attorney, Agent, or Firm* — Jack Jmaev

(57) **ABSTRACT**

A luminary dimming system having a three terminal dimming unit. The dimming unit includes a power controller and a receiver and is responsive to dimming directives received by the receiver. The power controller controls a buck switch and a freewheel switch in a manner that allows reduction of alternating current voltages. Such voltage reduction is accomplished in a manner that preserves the waveform of the source voltage and the power factor exhibited by the luminary.

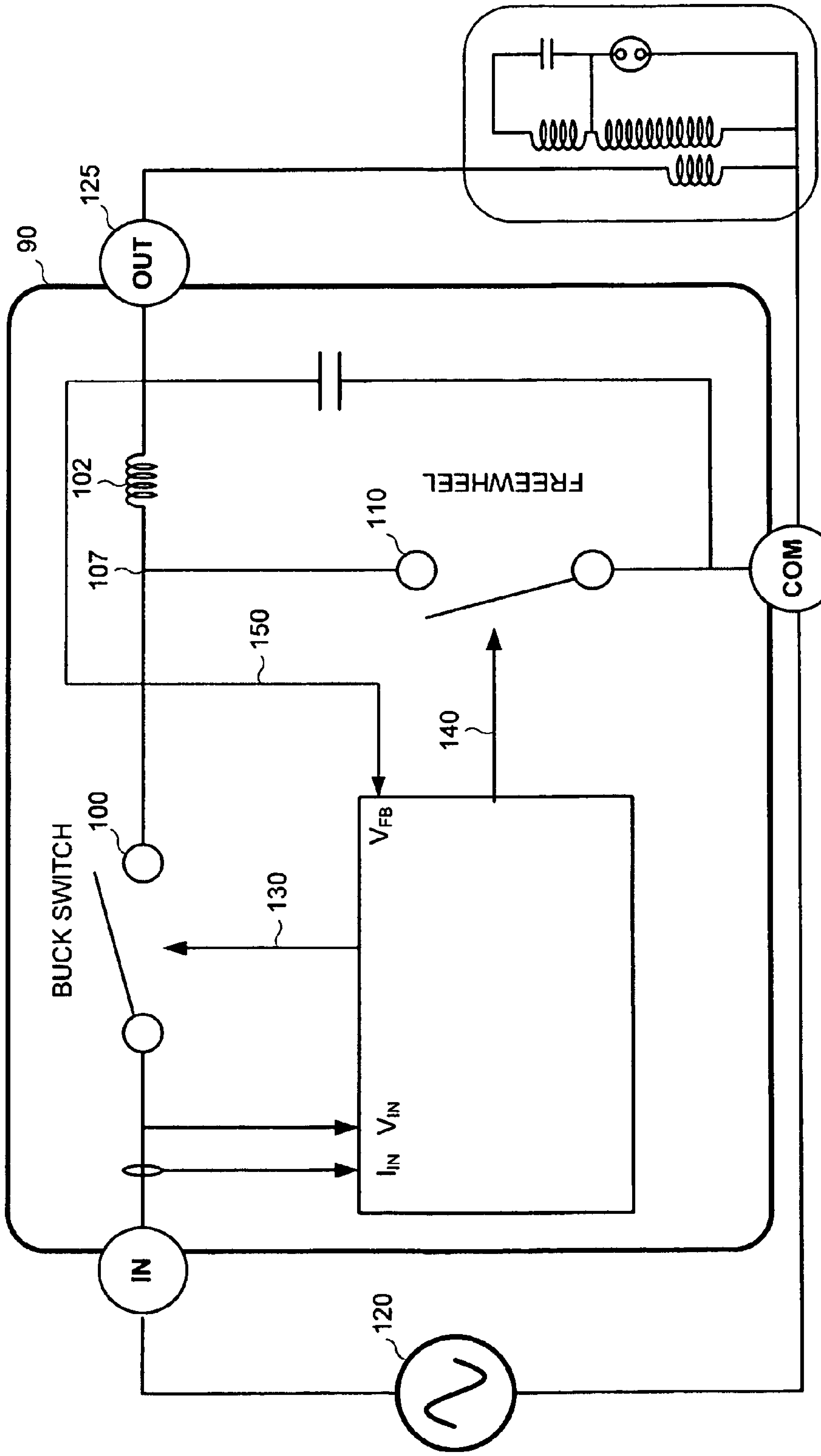
6 Claims, 28 Drawing Sheets





PRIOR ART

FIG. 1



PRIOR ART

FIG. 2

PRIOR ART

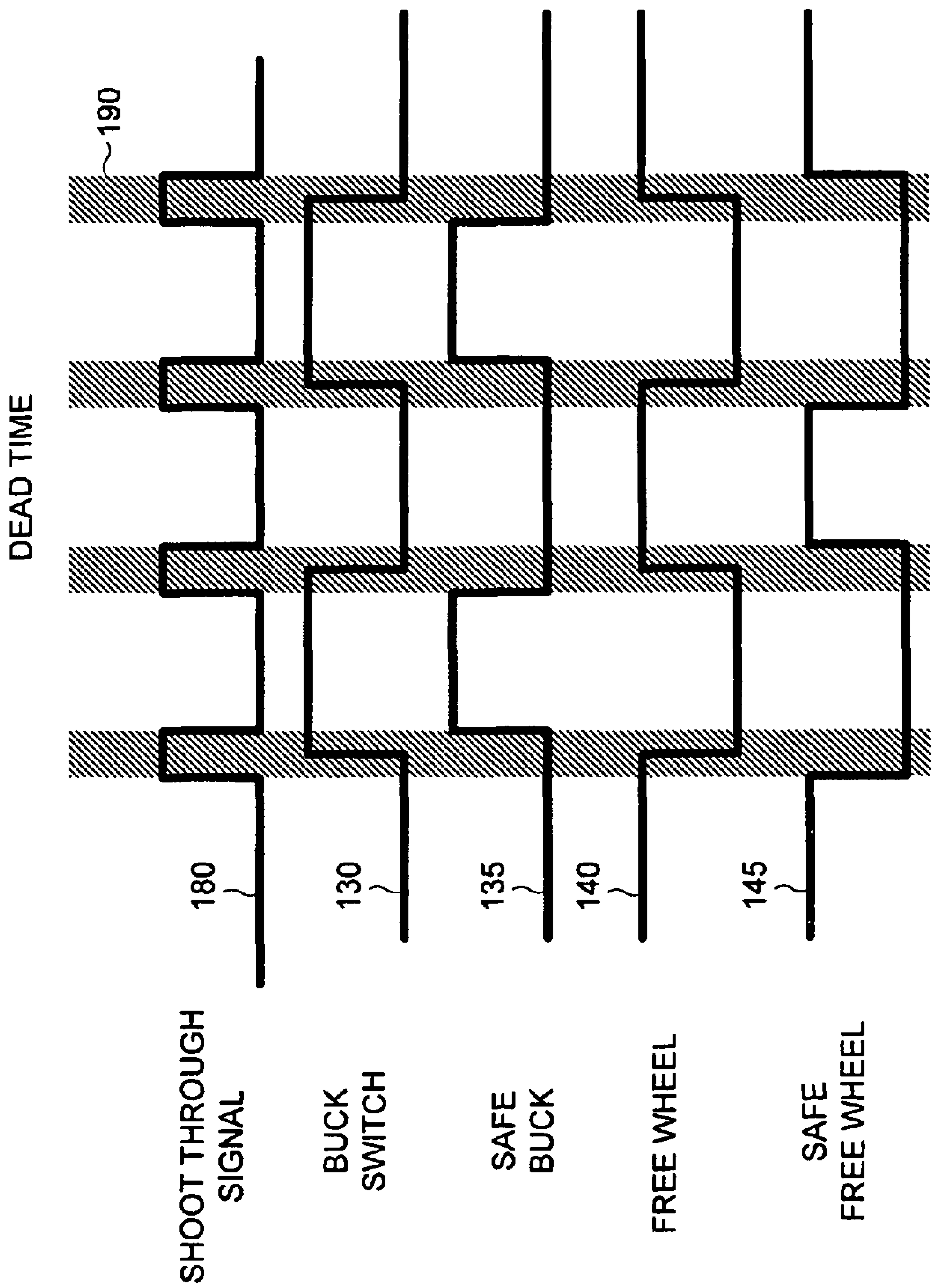


FIG. 3

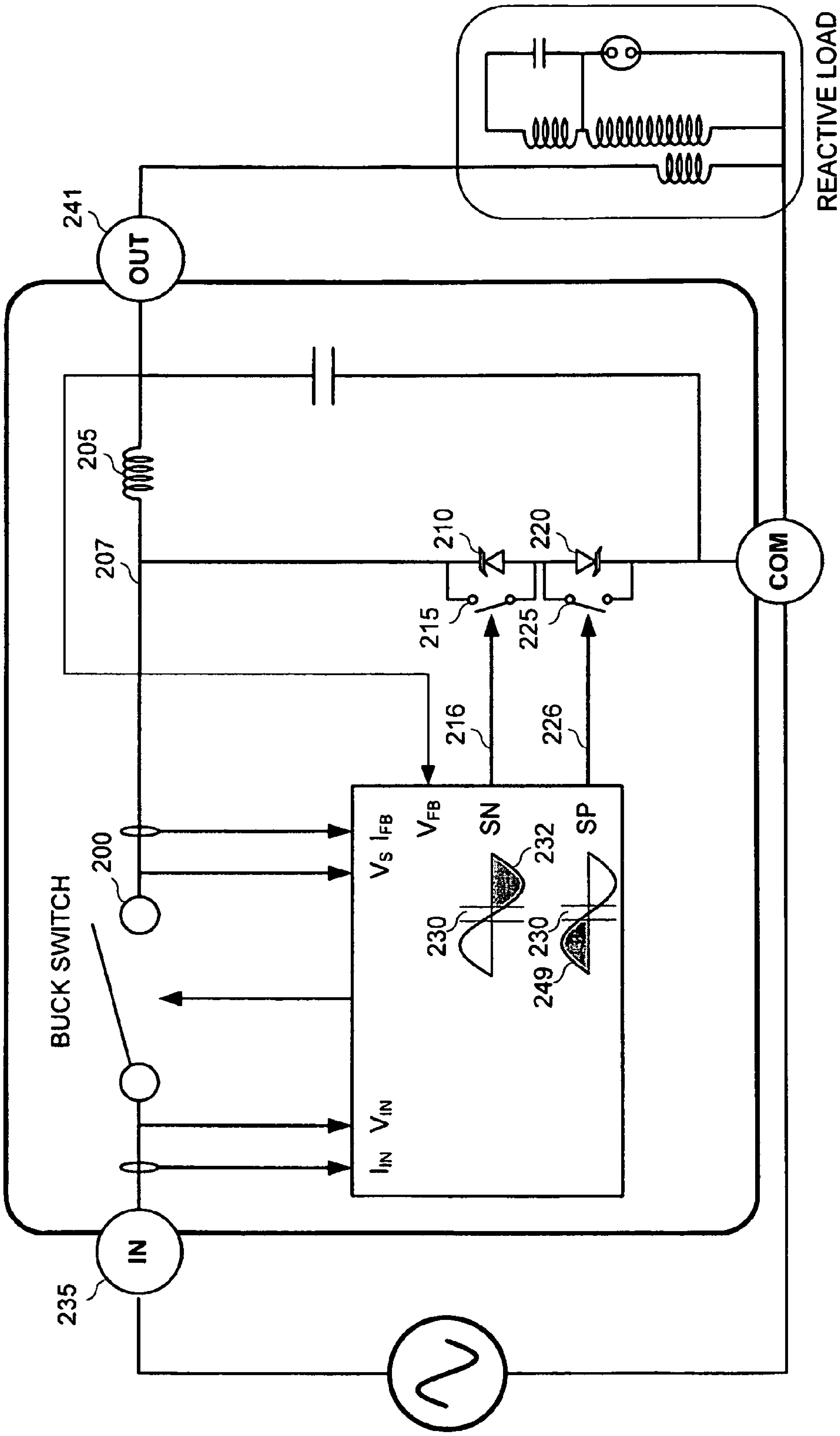

REACTIVE LOAD
241
OUT
205
207
210
220
215
225
COM
216
226
BUCK SWITCH
200
V_S I_{FB}
V_{FB}
SN
SP
230
232
230
249
I_{IN} V_{IN}
IN
235

FIG. 4

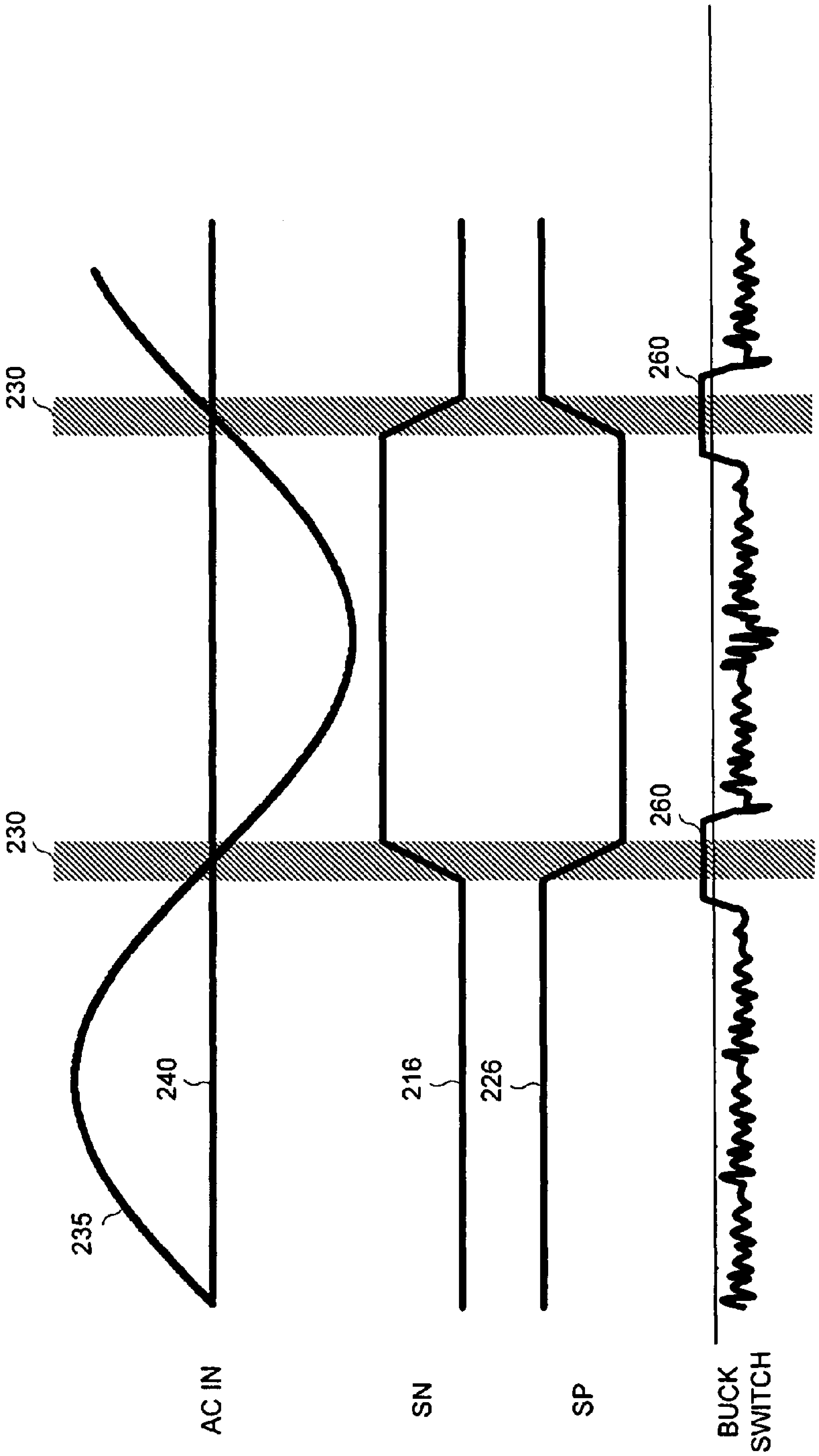
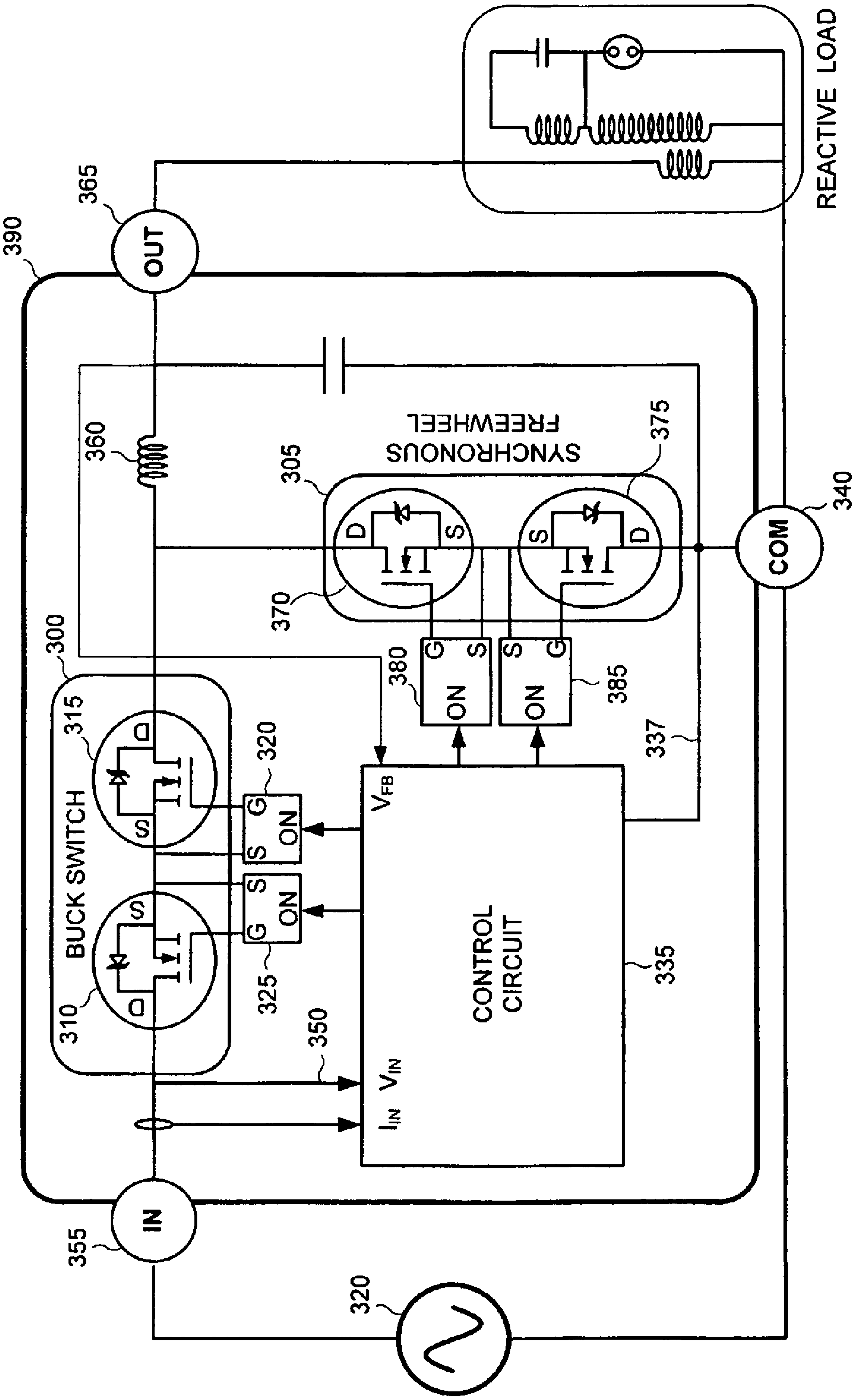


FIG. 5



390
365
OUT
REACTIVE LOAD
360
SYNCHRONOUS
FREEWHEEL
305
375
340
COM
D
S
G
ON
370
300
BUCK SWITCH
315
380
385
320
337
V_{FB}
CONTROL
CIRCUIT
335
310
325
350
V_{IN}
I_{IN}
IN
355

FIG. 6

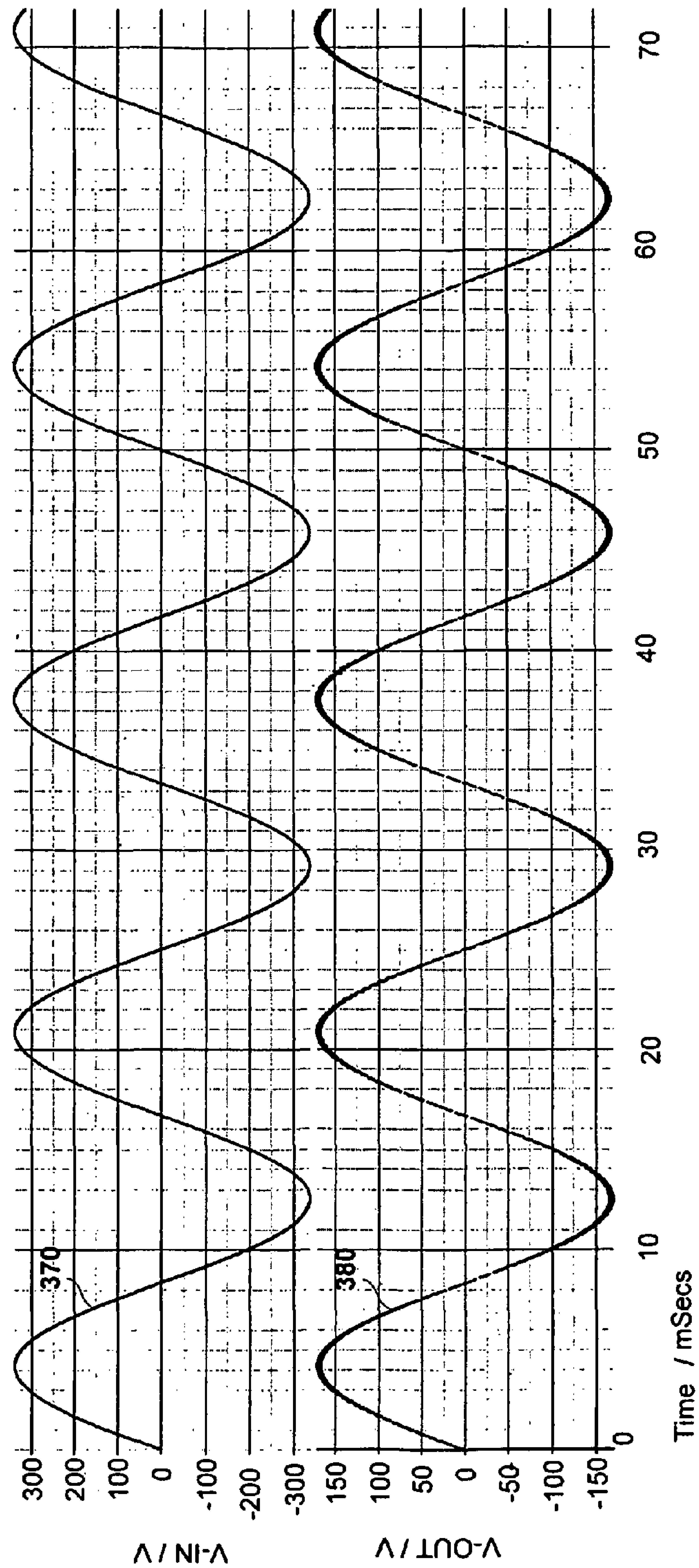

V-IN / V
300
200
100
0
-100
-200
-300
V-OUT / V
150
100
50
0
-50
-100
-150
370
380
0
10
20
30
40
50
60
70
Time / mSecs

FIG. 7

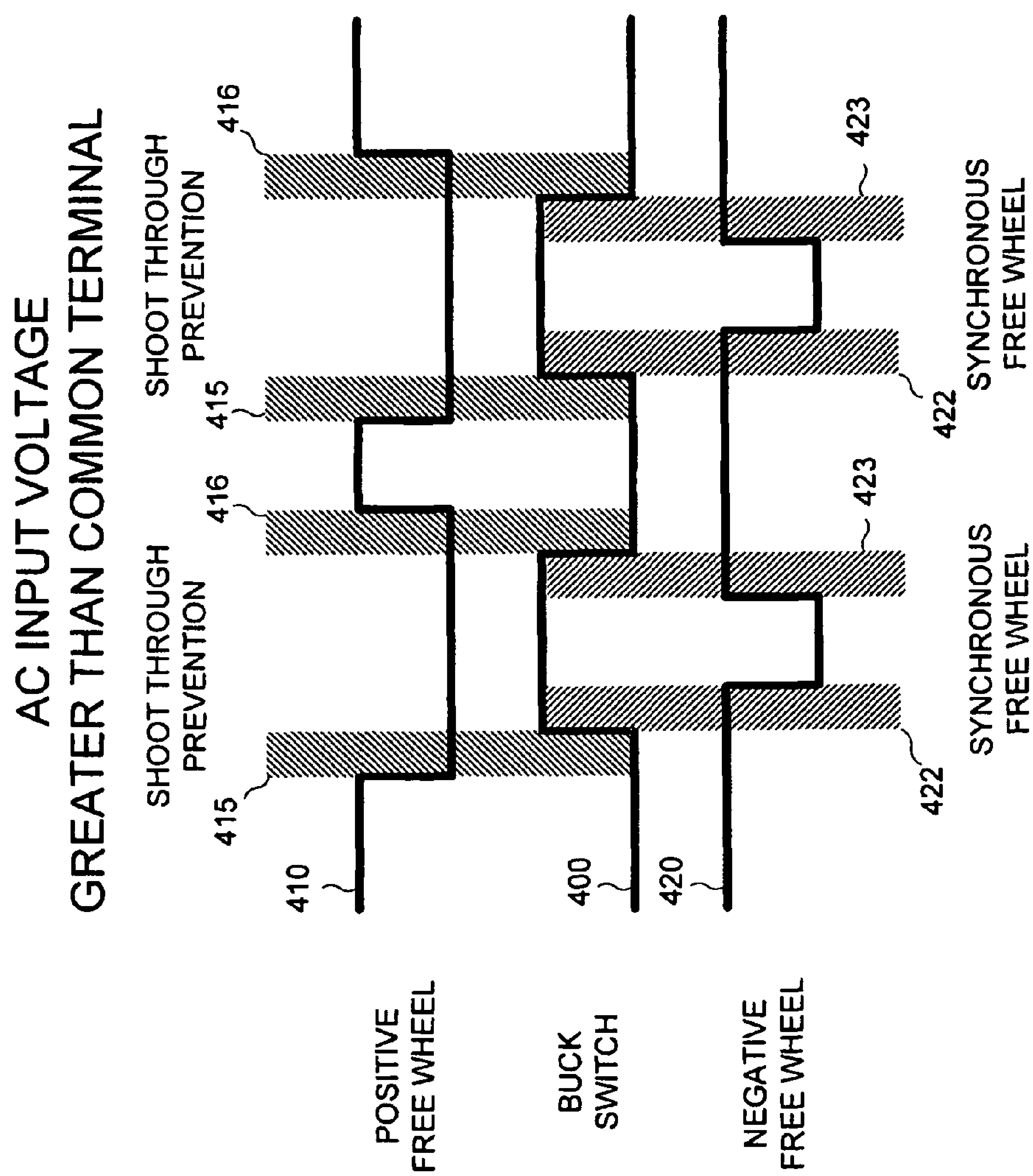

AC INPUT VOLTAGE
GREATER THAN COMMON TERMINAL
SHOOT THROUGH PREVENTION
SHOOT THROUGH PREVENTION
415
416
415
416
410
400
420
422
423
422
423
SYNCHRONOUS FREE WHEEL
SYNCHRONOUS FREE WHEEL
POSITIVE FREE WHEEL
BUCK SWITCH
NEGATIVE FREE WHEEL

FIG. 8

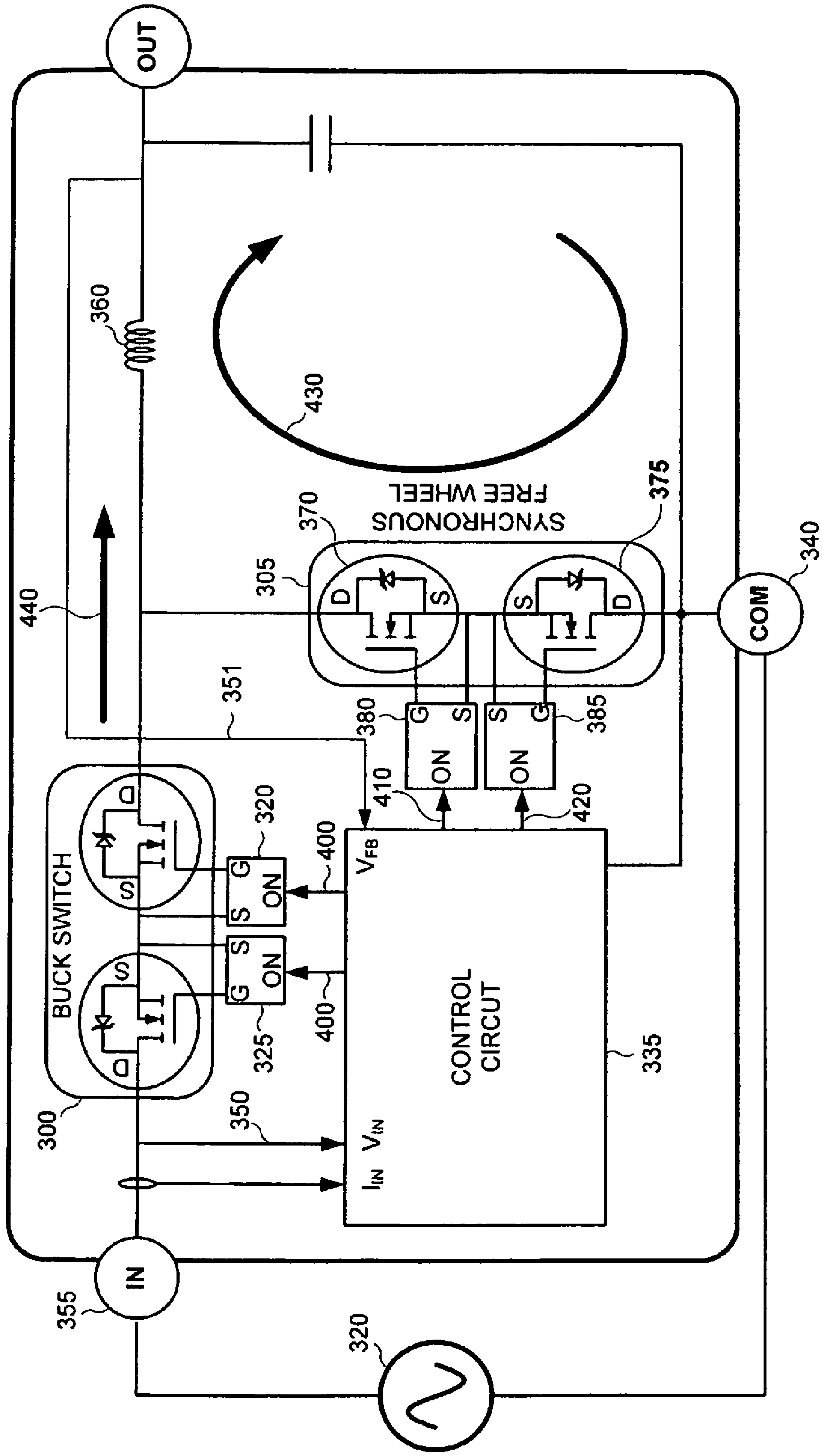

OUT
360
430
440
SYNCHRONOUS
FREE WHEEL
370
375
305
D
S
S
D
COM
340
351
380
G
S
S
G
385
ON
ON
410
420
BUCK SWITCH
S
D
S
D
G
S
S
G
ON
ON
320
400
400
325
300
V_{FB}
CONTROL
CIRCUIT
335
350
V_{IN}
I_{IN}
IN
355
320

FIG. 9

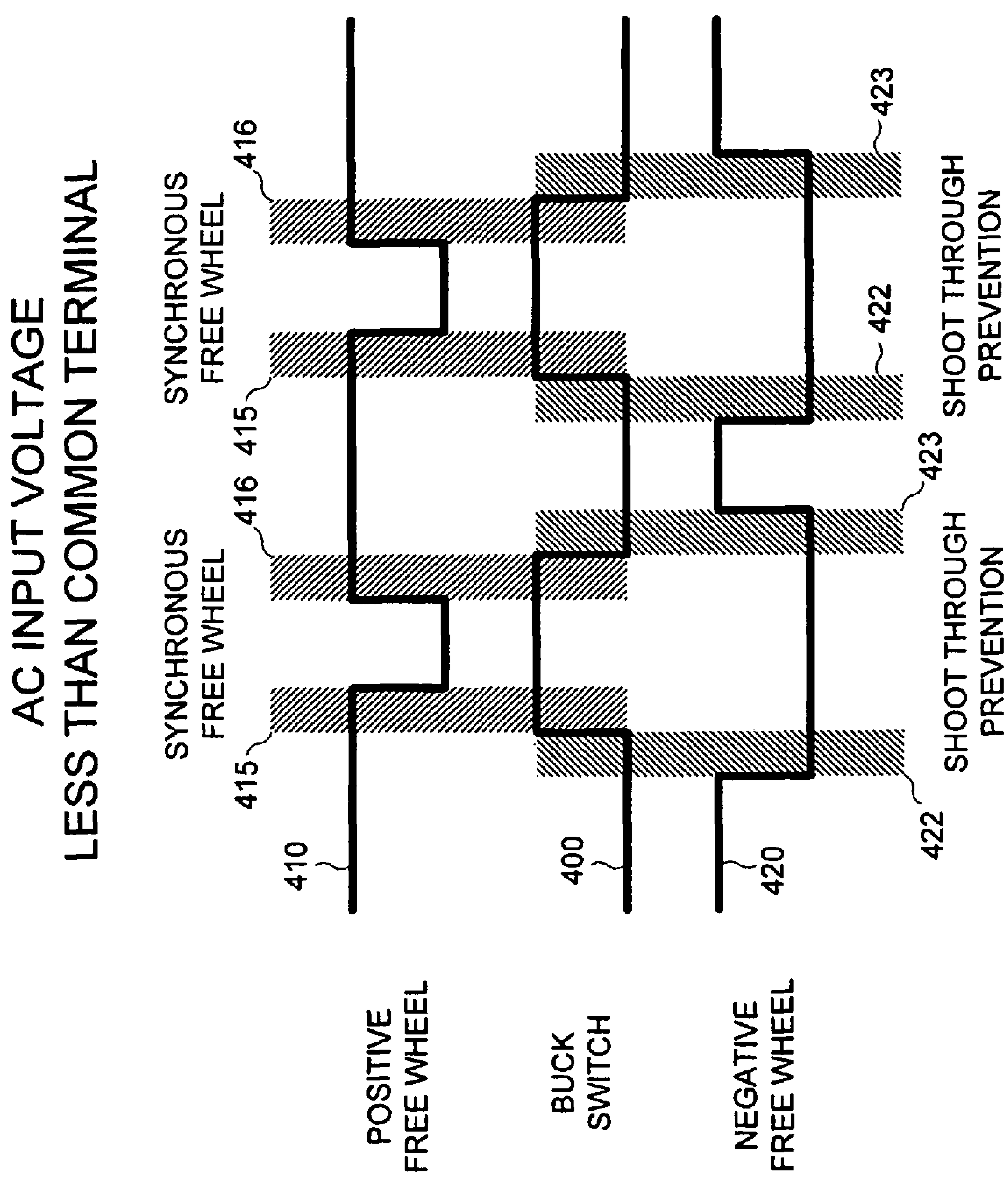

AC INPUT VOLTAGE
LESS THAN COMMON TERMINAL
SYNCHRONOUS FREE WHEEL
SYNCHRONOUS FREE WHEEL
SHOOT THROUGH PREVENTION
SHOOT THROUGH PREVENTION
POSITIVE FREE WHEEL
BUCK SWITCH
NEGATIVE FREE WHEEL
410
400
420
415
416
415
416
422
423
422
423

FIG. 10

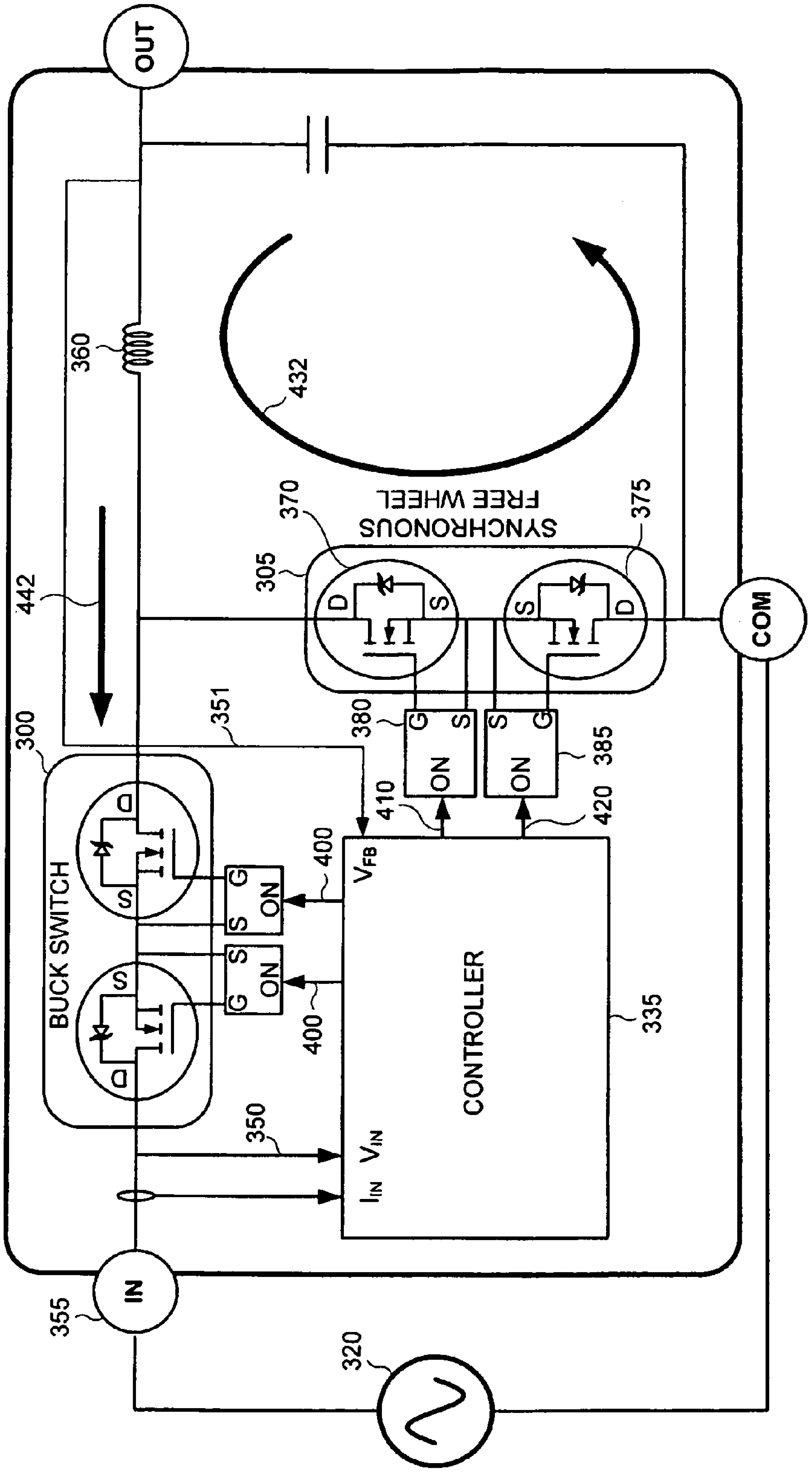

OUT
360
432
442
305
370
375
SYNCHRONOUS
FREE WHEEL
D
S
S
D
COM
300
351
380
385
G S
S G
ON
ON
410
420
BUCK SWITCH
D
S
S
D
G
S
S
G
ON
ON
400
400
V_{FB}
CONTROLLER
335
350
V_{IN}
I_{IN}
IN
355
320

FIG. 11

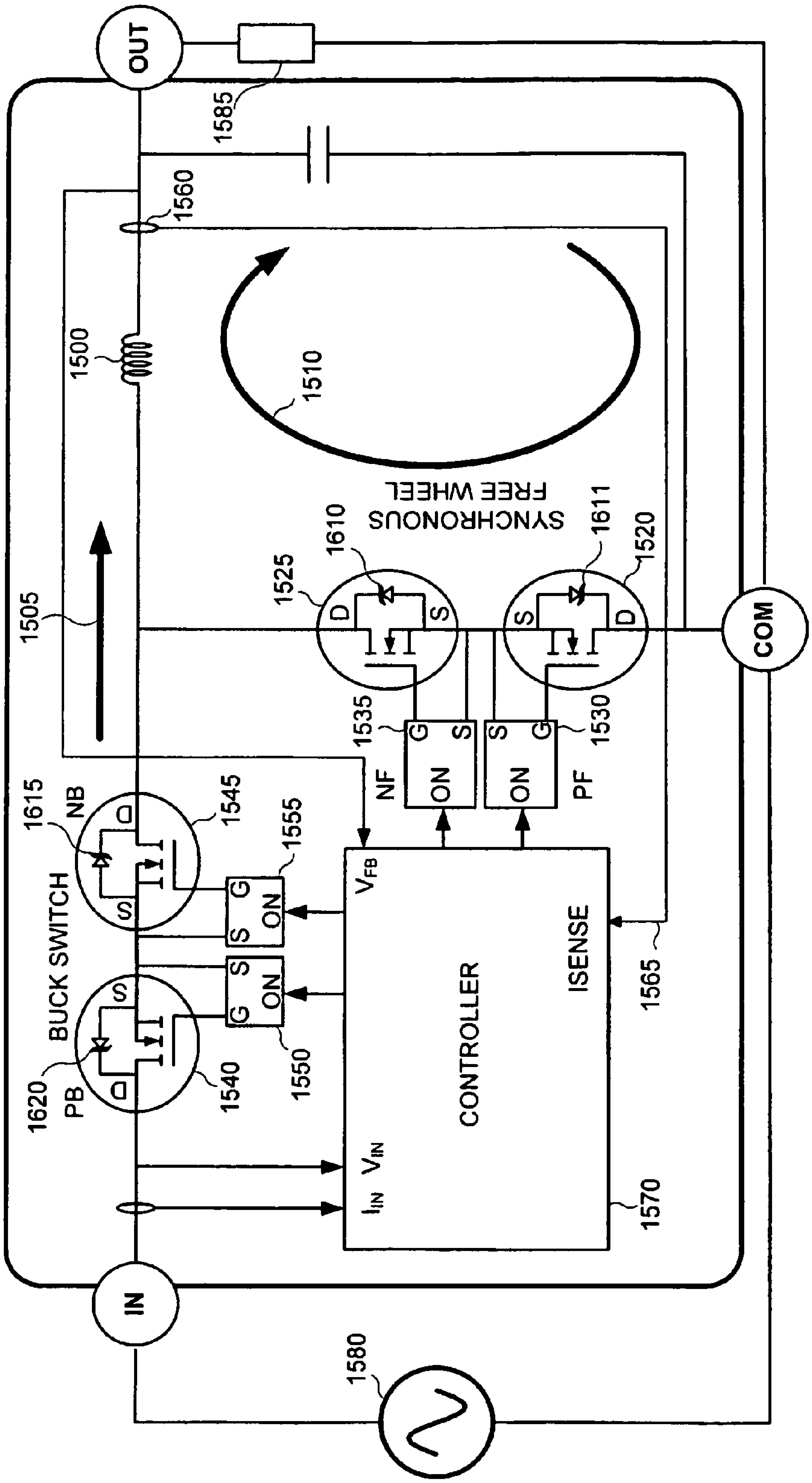

OUT
1585
1560
1500
1510
1505
SYNCHRONOUS
FREE WHEEL
1610
1525
1611
1520
D
S
COM
1535
1530
G
S
ON
NF
PF
BUCK SWITCH
1615
NB
1620
PB
1545
1540
1555
1550
V_{FB}
CONTROLLER
ISENSE
1565
I_{IN}
V_{IN}
1570
IN
1580

FIG. 11A

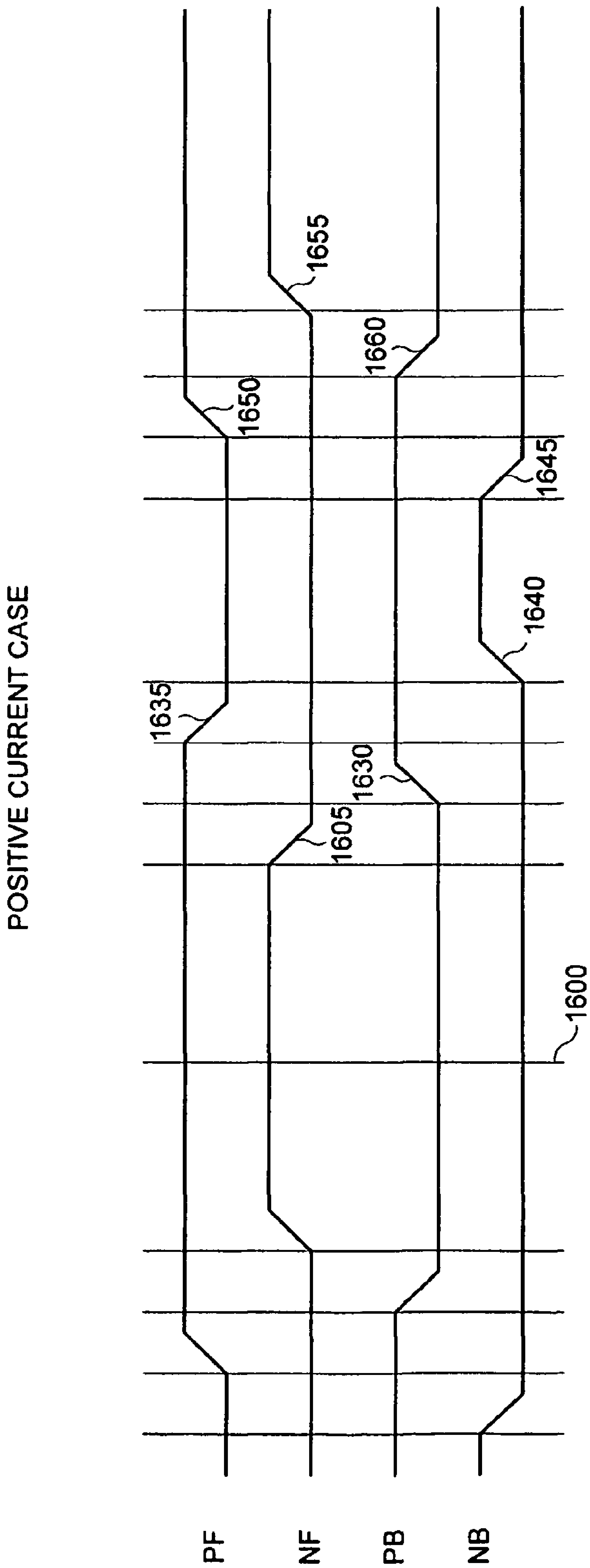

POSITIVE CURRENT CASE
PF
NF
PB
NB
1600
1605
1630
1635
1640
1645
1650
1655
1660

FIG. 11B

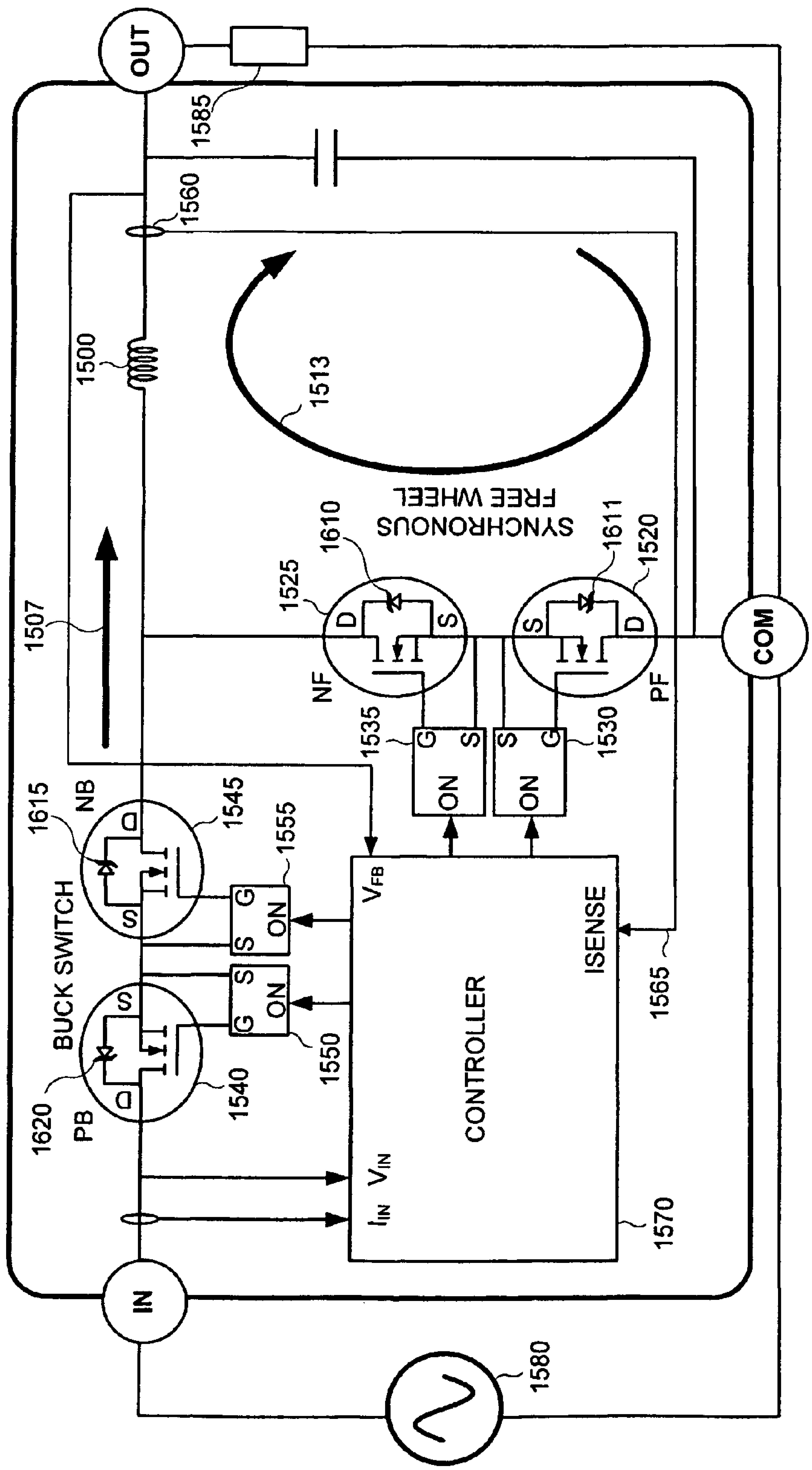

OUT
1585
1560
1500
1513
SYNCHRONOUS
FREE WHEEL
1507
1525
1610
1611
1520
NF
PF
COM
1535
1530
G S
S G
ON
ON
NB
1615
1545
1555
BUCK SWITCH
S D
D S
G S ON
S G ON
V_{FB}
ISENSE
1565
CONTROLLER
1550
1540
1620
PB
V_{IN}
I_{IN}
1570
IN
1580

FIG. 11C

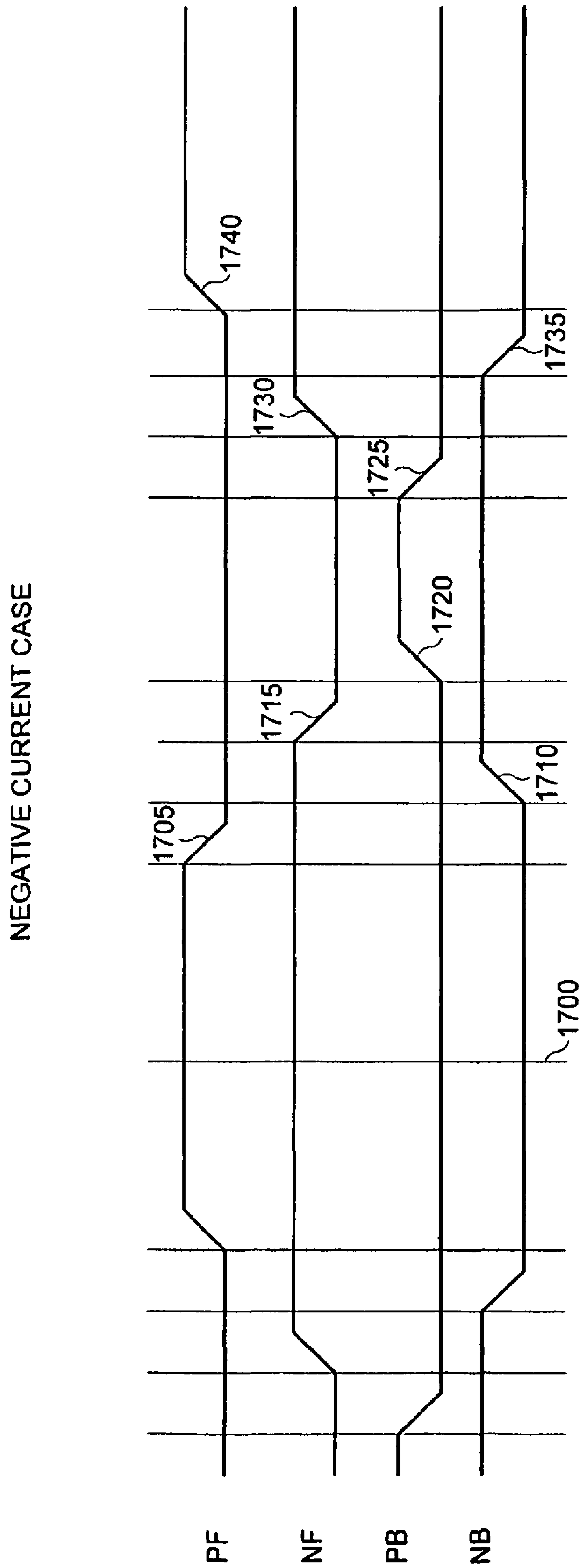

NEGATIVE CURRENT CASE
1740
1735
1730
1725
1720
1715
1710
1705
1700
PF
NF
PB
NB

FIG. 11D

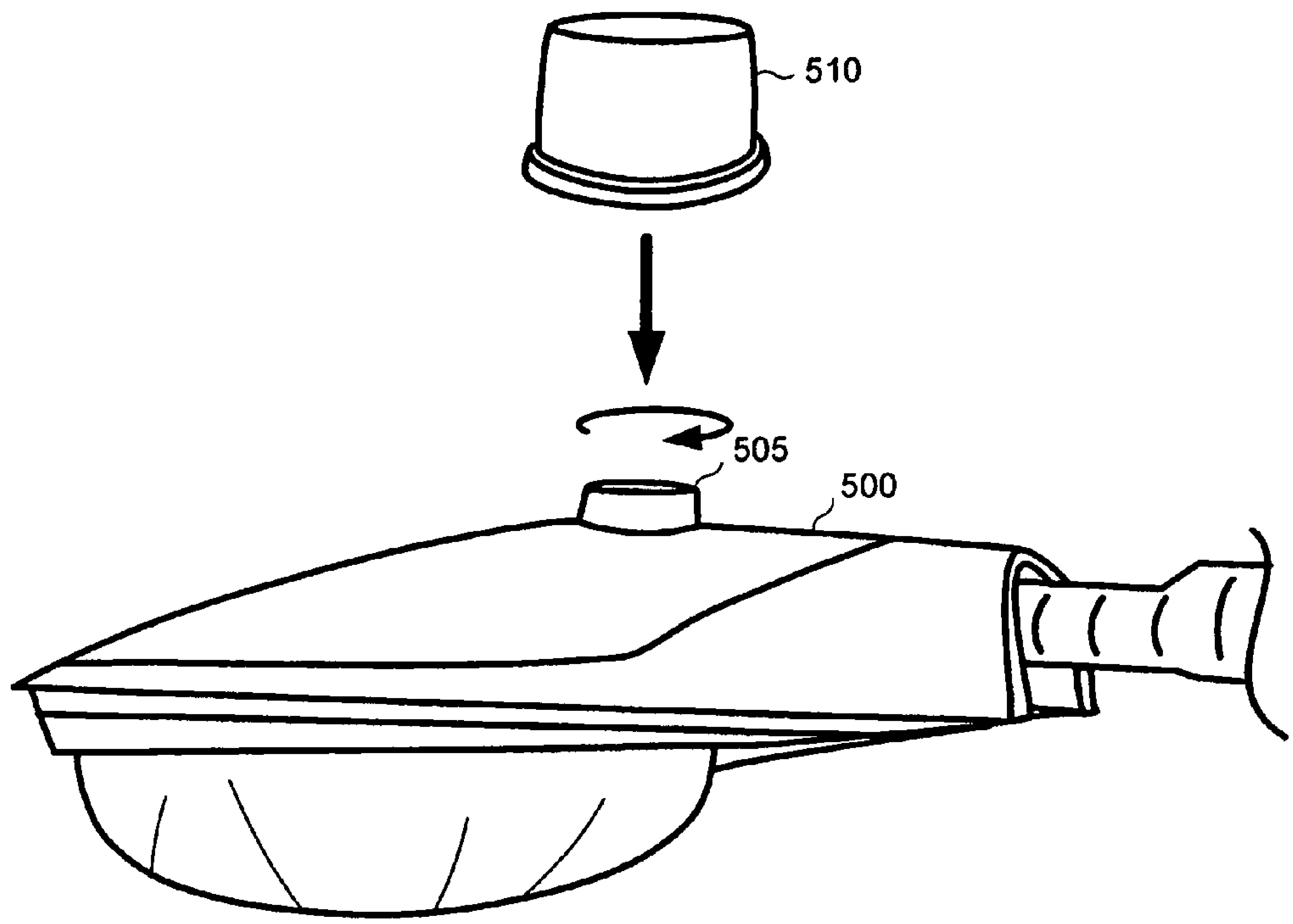


FIG. 12

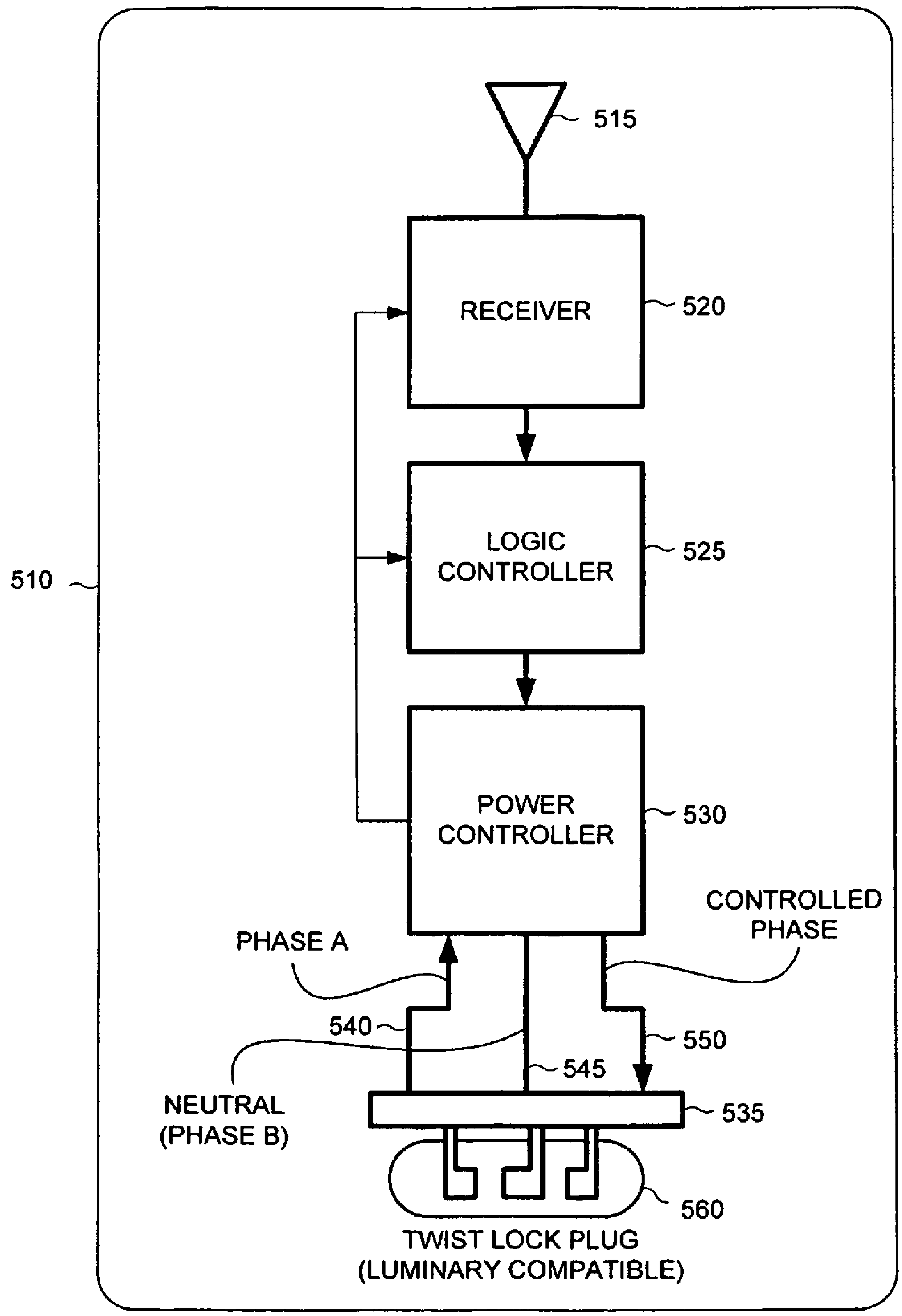

515
RECEIVER
520
LOGIC CONTROLLER
525
510
POWER CONTROLLER
530
CONTROLLED PHASE
PHASE A
540
550
545
NEUTRAL (PHASE B)
535
560
TWIST LOCK PLUG (LUMINARY COMPATIBLE)

FIG. 13

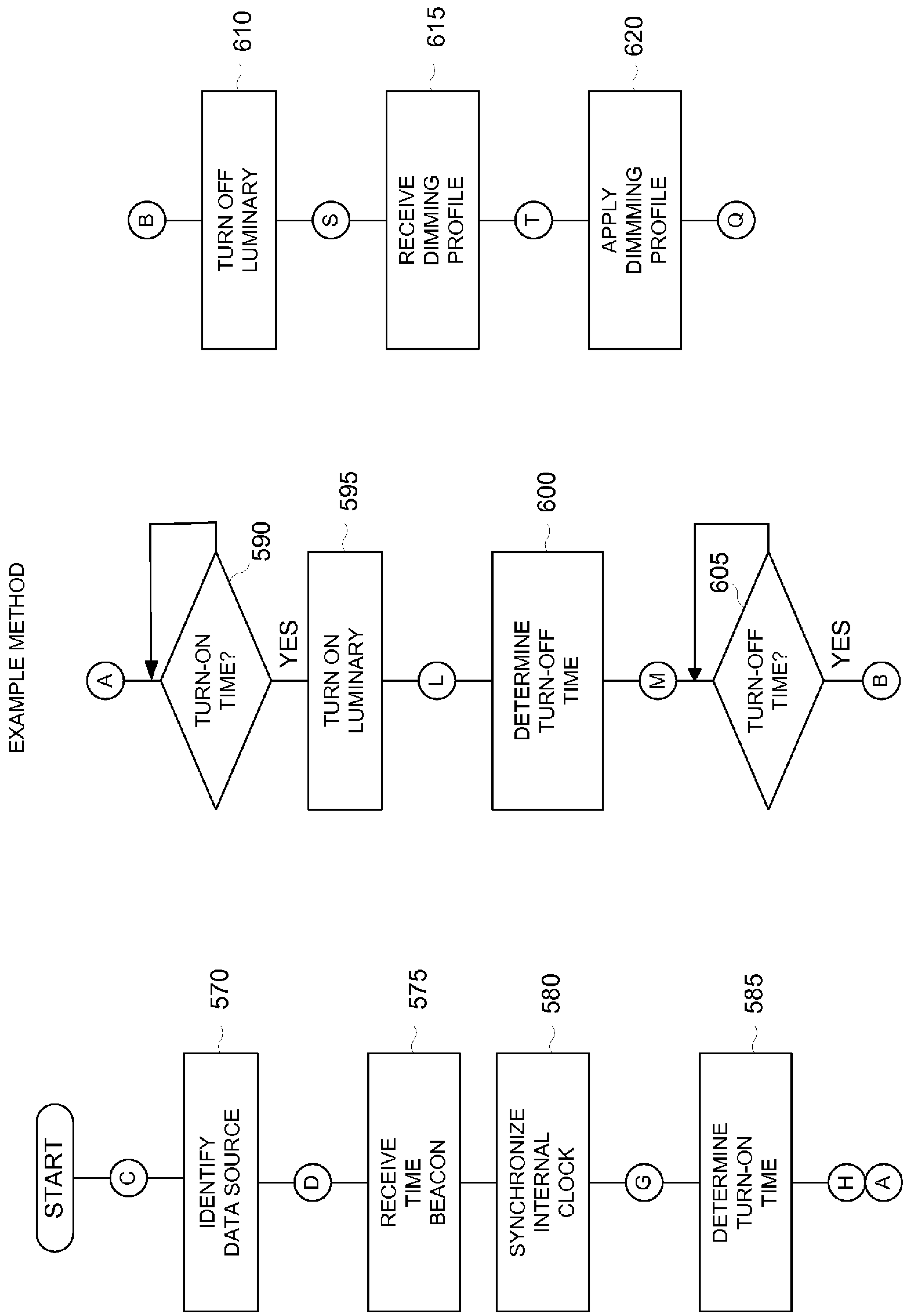

EXAMPLE METHOD
START
C
IDENTIFY DATA SOURCE
570
D
RECEIVE TIME BEACON
575
SYNCHRONIZE INTERNAL CLOCK
580
G
DETERMINE TURN-ON TIME
585
H
A
A
TURN-ON TIME?
590
YES
TURN ON LUMINARY
595
L
DETERMINE TURN-OFF TIME
600
M
TURN-OFF TIME?
605
YES
B
B
TURN OFF LUMINARY
610
S
RECEIVE DIMMING PROFILE
615
T
APPLY DIMMMING PROFILE
620
Q

FIG. 14

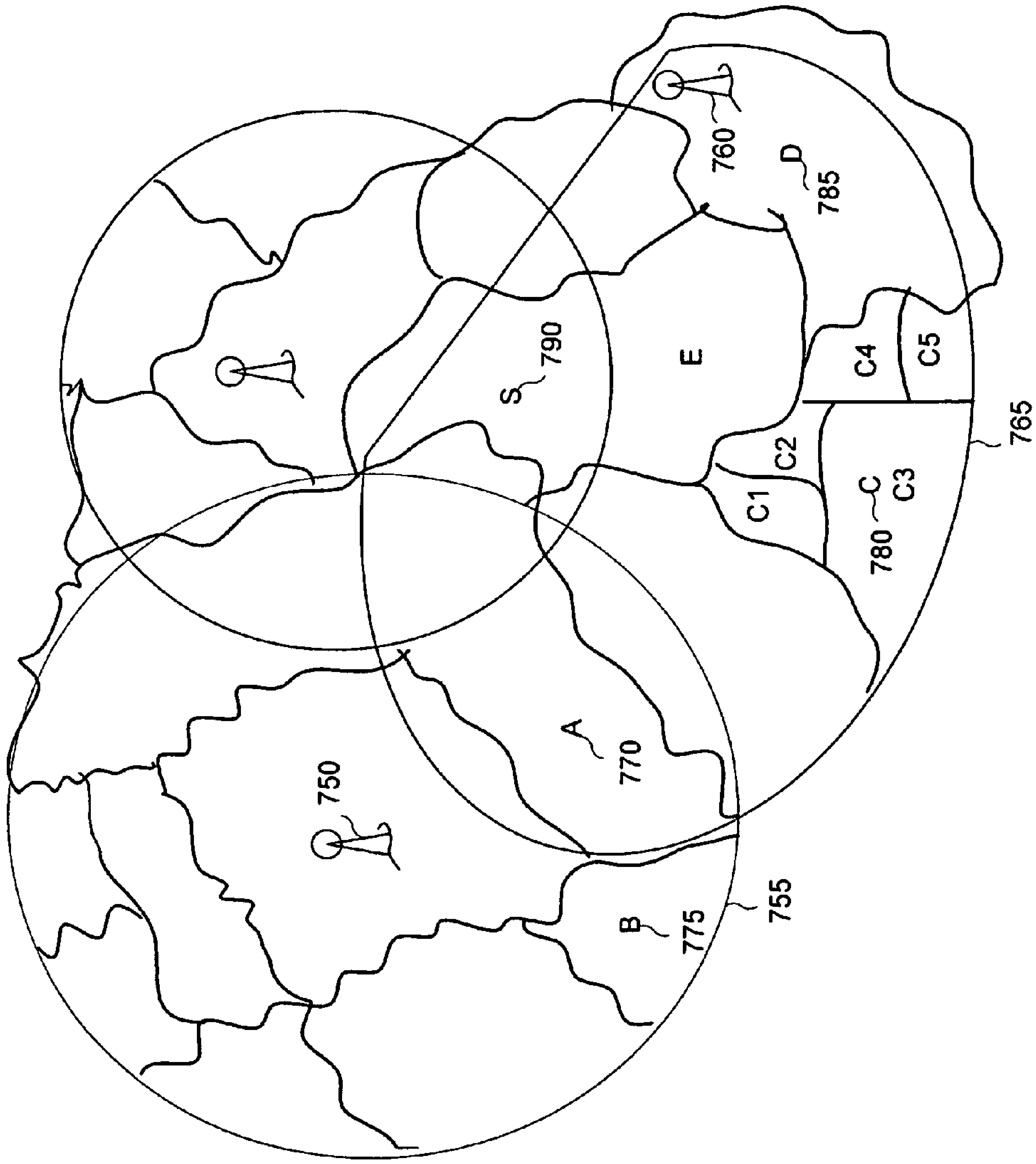


FIG.14A

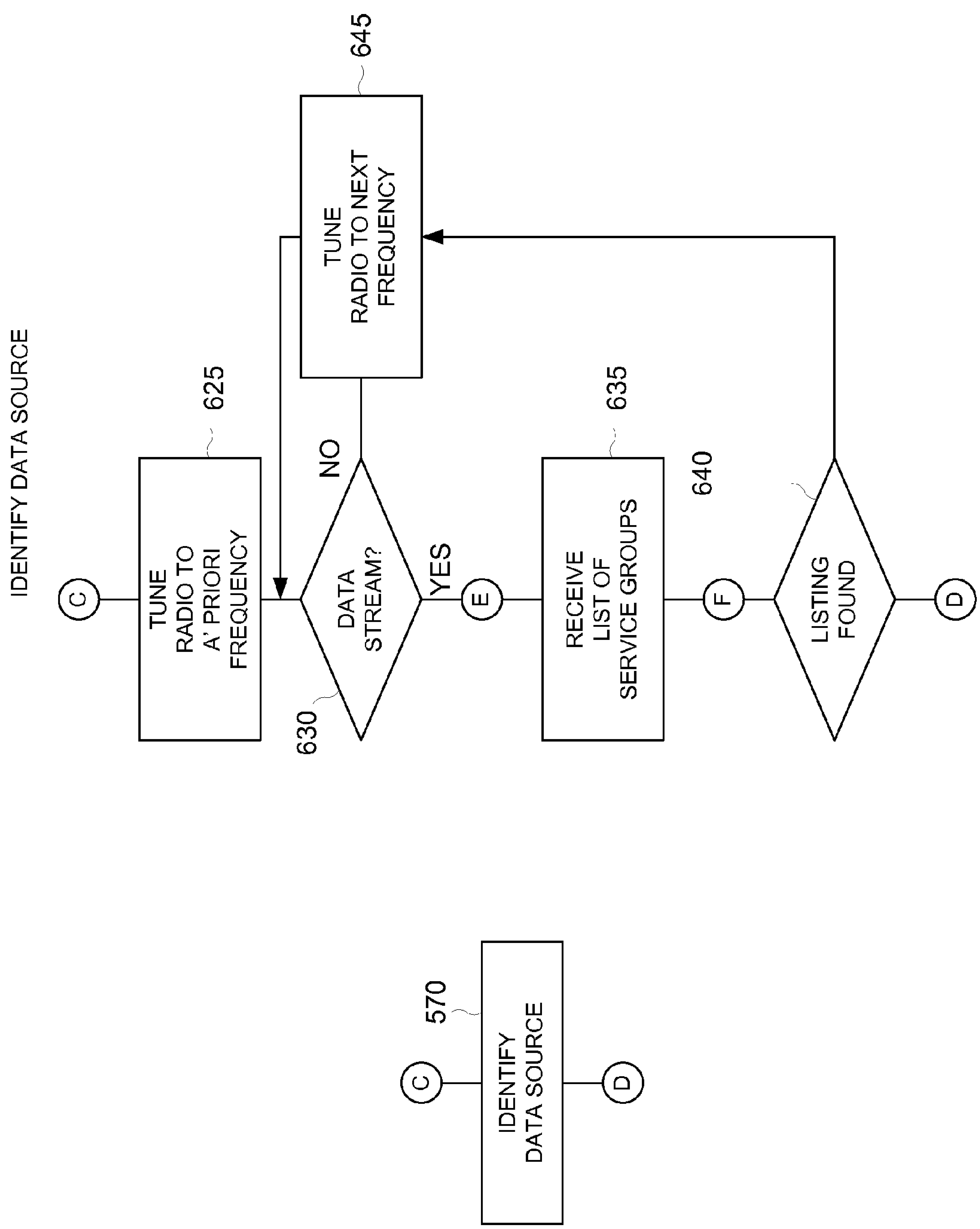

IDENTIFY DATA SOURCE
C
TUNE RADIO TO A' PRIORI FREQUENCY
625
DATA STREAM?
630
NO
YES
TUNE RADIO TO NEXT FREQUENCY
645
E
RECEIVE LIST OF SERVICE GROUPS
635
F
640
LISTING FOUND
D
570
C
IDENTIFY DATA SOURCE
D

FIG. 15

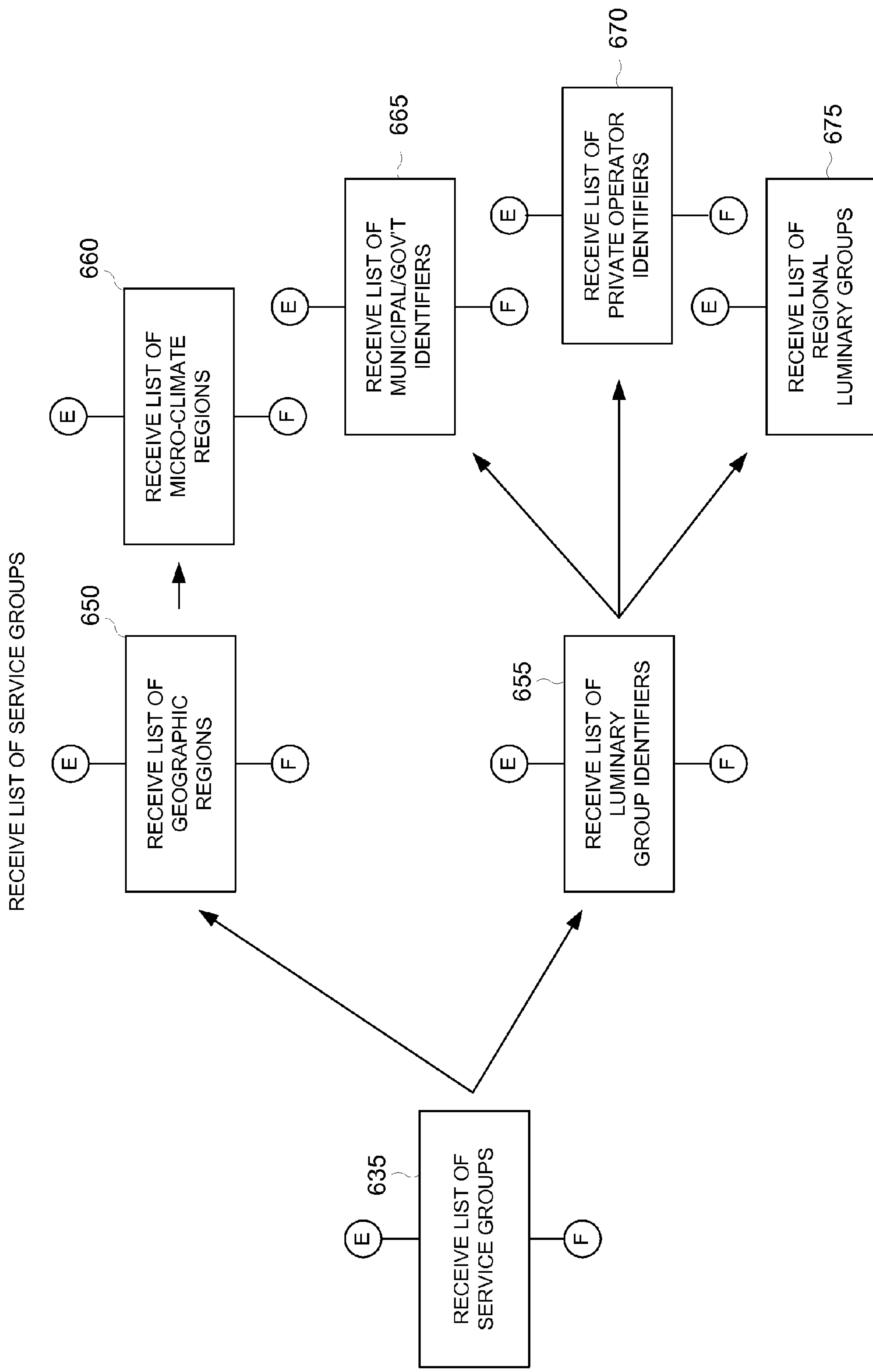

RECEIVE LIST OF SERVICE GROUPS
635
RECEIVE LIST OF SERVICE GROUPS
650
RECEIVE LIST OF GEOGRAPHIC REGIONS
655
RECEIVE LIST OF LUMINARY GROUP IDENTIFIERS
660
RECEIVE LIST OF MICRO-CLIMATE REGIONS
665
RECEIVE LIST OF MUNICIPAL/GOV'T IDENTIFIERS
670
RECEIVE LIST OF PRIVATE OPERATOR IDENTIFIERS
675
RECEIVE LIST OF REGIONAL LUMINARY GROUPS
E
F

FIG.16

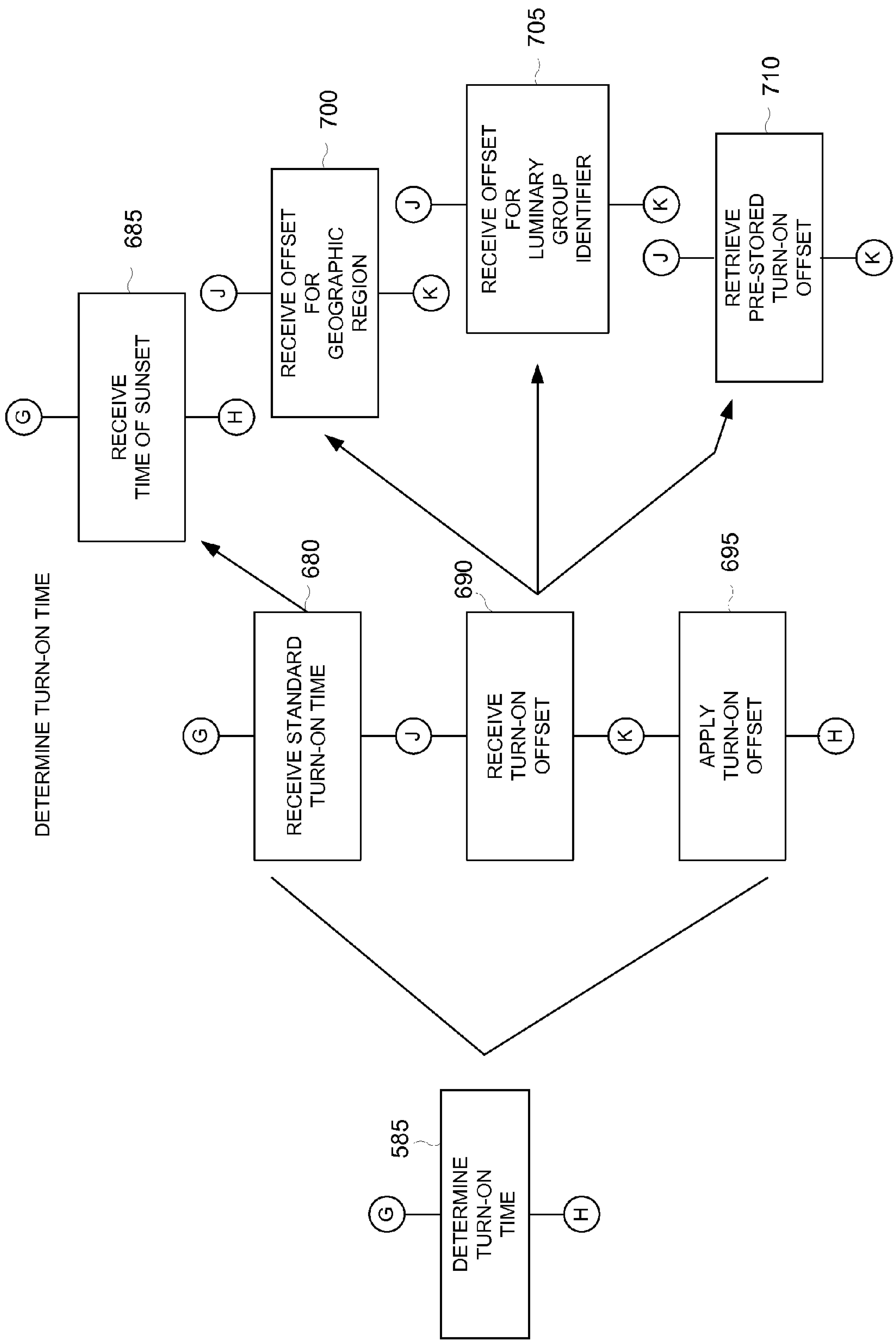
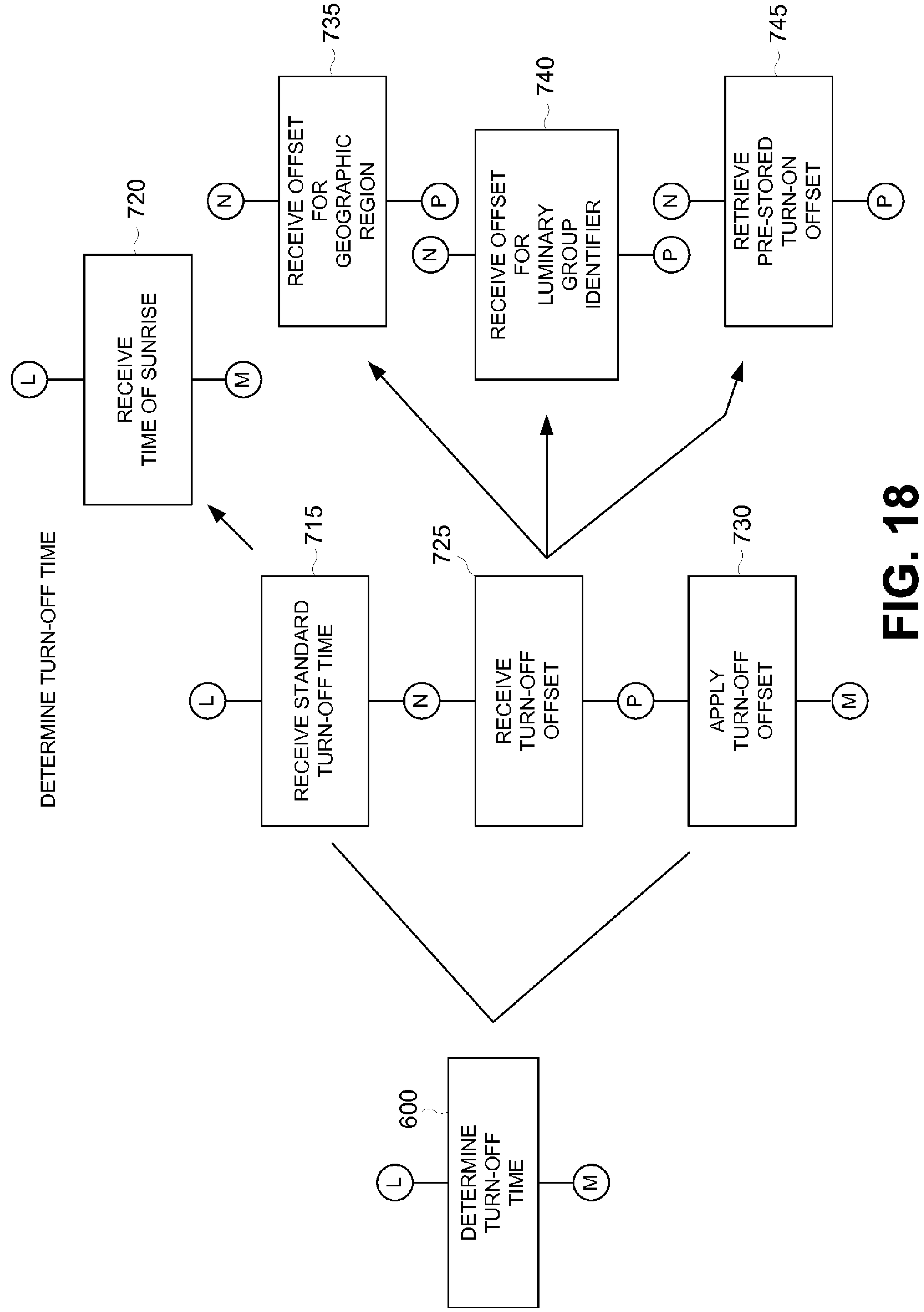

DETERMINE TURN-ON TIME
585
DETERMINE TURN-ON TIME
G
H
680
RECEIVE STANDARD TURN-ON TIME
690
RECEIVE TURN-ON OFFSET
695
APPLY TURN-ON OFFSET
J
K
685
RECEIVE TIME OF SUNSET
700
RECEIVE OFFSET FOR GEOGRAPHIC REGION
705
RECEIVE OFFSET FOR LUMINARY GROUP IDENTIFIER
710
RETRIEVE PRE-STORED TURN-ON OFFSET

FIG. 17



DETERMINE TURN-OFF TIME
600
DETERMINE TURN-OFF TIME
L
M
715
RECEIVE STANDARD TURN-OFF TIME
725
RECEIVE TURN-OFF OFFSET
730
APPLY TURN-OFF OFFSET
N
P
720
RECEIVE TIME OF SUNRISE
735
RECEIVE OFFSET FOR GEOGRAPHIC REGION
740
RECEIVE OFFSET FOR LUMINARY GROUP IDENTIFIER
745
RETRIEVE PRE-STORED TURN-ON OFFSET

FIG. 18

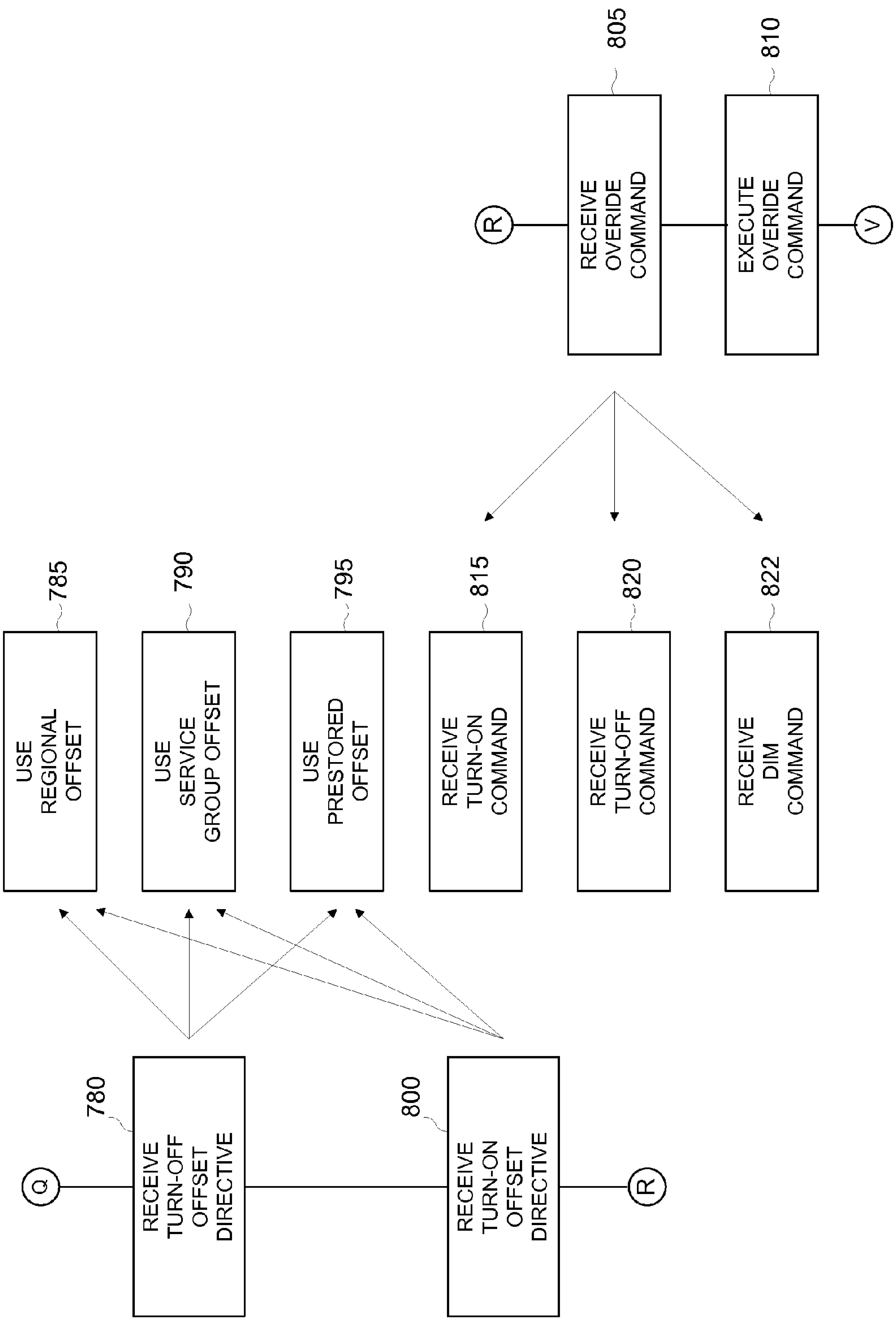

Q
RECEIVE TURN-OFF OFFSET DIRECTIVE
780
RECEIVE TURN-ON OFFSET DIRECTIVE
800
R
USE REGIONAL OFFSET
785
USE SERVICE GROUP OFFSET
790
USE PRESTORED OFFSET
795
RECEIVE TURN-ON COMMAND
815
RECEIVE TURN-OFF COMMAND
820
RECEIVE DIM COMMAND
822
R
RECEIVE OVERIDE COMMAND
805
EXECUTE OVERIDE COMMAND
810
V

FIG. 19

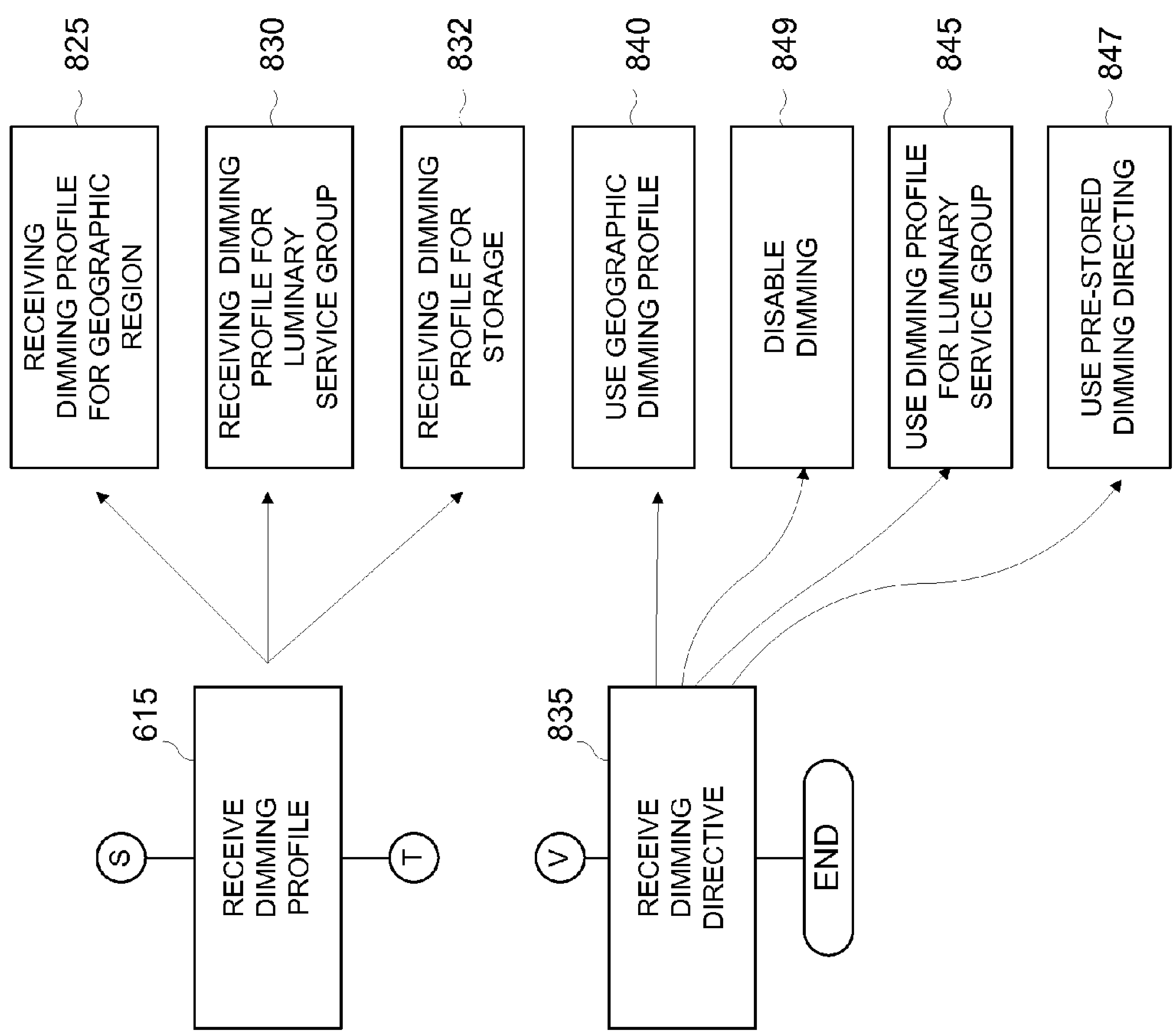
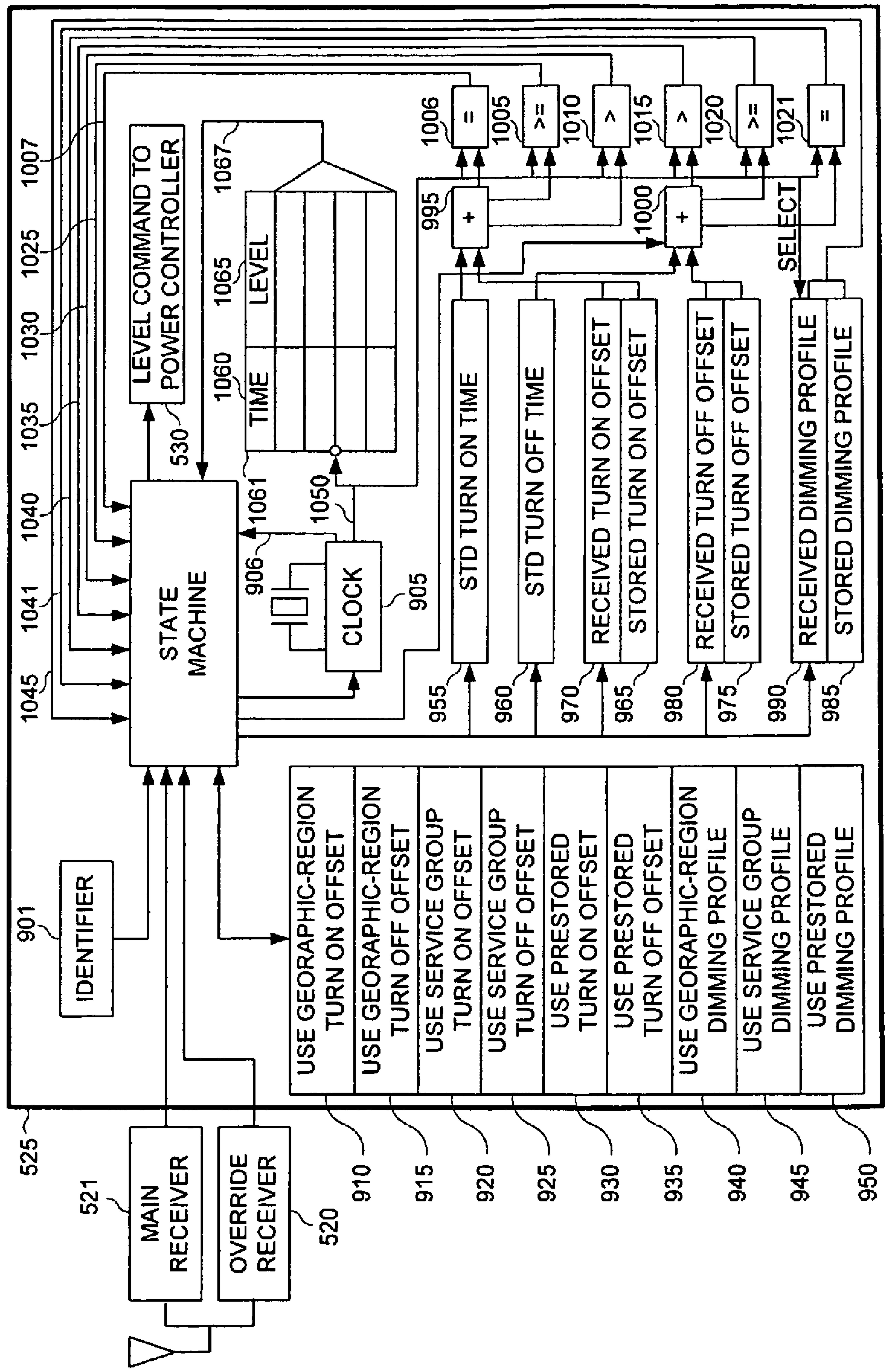
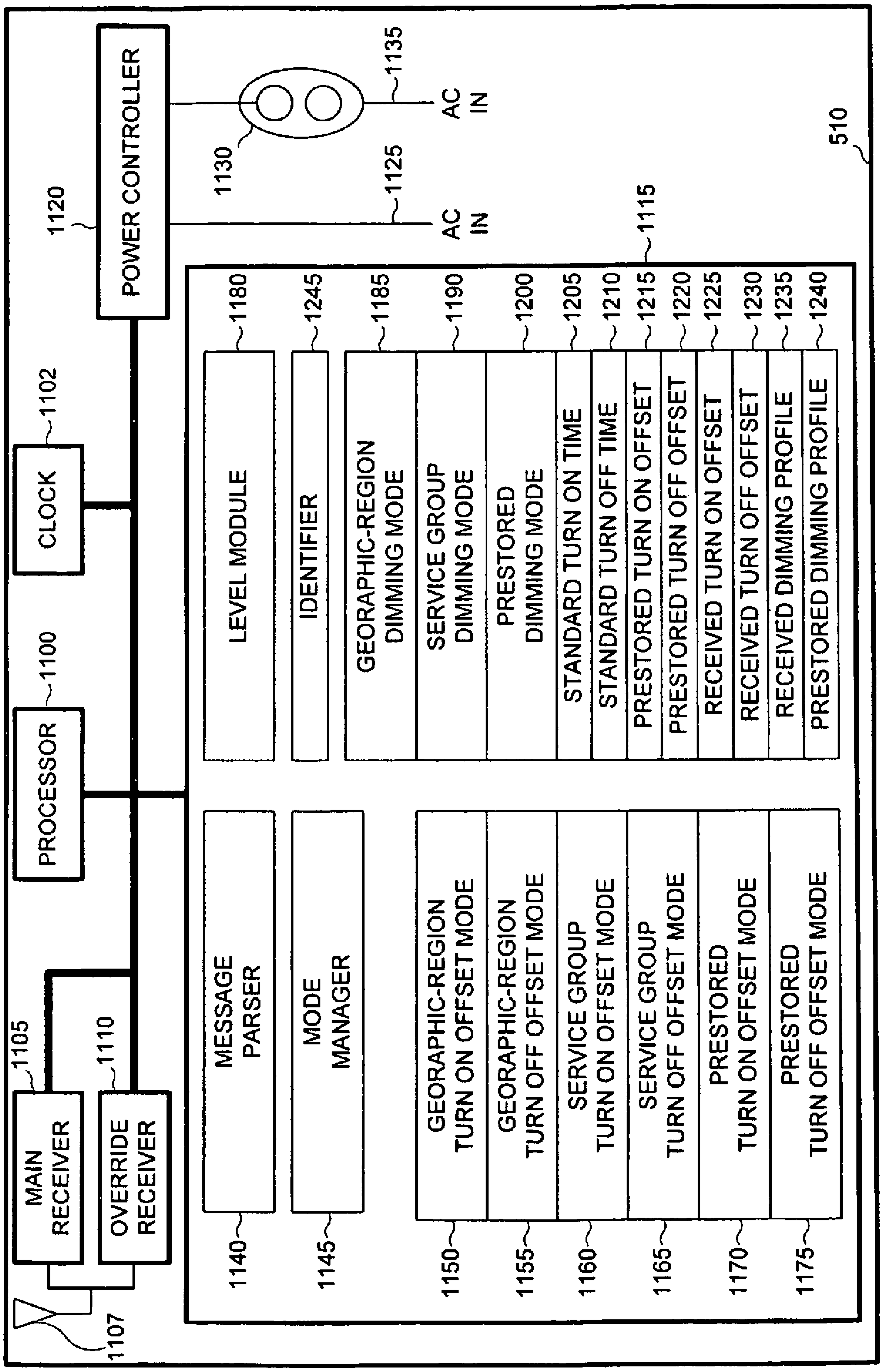

S
RECEIVE DIMMING PROFILE
615
T
RECEIVING DIMMING PROFILE FOR GEOGRAPHIC REGION
825
RECEIVING DIMMING PROFILE FOR LUMINARY SERVICE GROUP
830
RECEIVING DIMMING PROFILE FOR STORAGE
832
V
RECEIVE DIMMING DIRECTIVE
835
END
USE GEOGRAPHIC DIMMING PROFILE
840
DISABLE DIMMING
849
USE DIMMING PROFILE FOR LUMINARY SERVICE GROUP
845
USE PRE-STORED DIMMING DIRECTING
847

FIG. 20



IDENTIFIER
901
STATE MACHINE
LEVEL COMMAND TO POWER CONTROLLER
530
CLOCK
905
906
1050
1061
TIME
LEVEL
1060
1065
1067
MAIN RECEIVER
521
OVERRIDE RECEIVER
520
525
1007
1025
1030
1035
1040
1041
1045
STD TURN ON TIME
STD TURN OFF TIME
RECEIVED TURN ON OFFSET
STORED TURN ON OFFSET
RECEIVED TURN OFF OFFSET
STORED TURN OFF OFFSET
RECEIVED DIMMING PROFILE
STORED DIMMING PROFILE
SELECT
955
960
970
965
980
975
990
985
995
1000
1006
1005
1010
1015
1020
1021
USE GEORAPHIC-REGION TURN ON OFFSET
USE GEORAPHIC-REGION TURN OFF OFFSET
USE SERVICE GROUP TURN ON OFFSET
USE SERVICE GROUP TURN OFF OFFSET
USE PRESTORED TURN ON OFFSET
USE PRESTORED TURN OFF OFFSET
USE GEORAPHIC-REGION DIMMING PROFILE
USE SERVICE GROUP DIMMING PROFILE
USE PRESTORED DIMMING PROFILE
910
915
920
925
930
935
940
945
950

FIG. 21



MAIN RECEIVER
1105
OVERRIDE RECEIVER
1110
1107
PROCESSOR
1100
CLOCK
1102
POWER CONTROLLER
1120
AC IN
1125
1130
1135
AC IN
510
1115
MESSAGE PARSER
1140
MODE MANAGER
1145
GEORAPHIC-REGION TURN ON OFFSET MODE
1150
GEORAPHIC-REGION TURN OFF OFFSET MODE
1155
SERVICE GROUP TURN ON OFFSET MODE
1160
SERVICE GROUP TURN OFF OFFSET MODE
1165
PRESTORED TURN ON OFFSET MODE
1170
PRESTORED TURN OFF OFFSET MODE
1175
LEVEL MODULE
1180
IDENTIFIER
1245
GEORAPHIC-REGION DIMMING MODE
1185
SERVICE GROUP DIMMING MODE
1190
PRESTORED DIMMING MODE
1200
STANDARD TURN ON TIME
1205
STANDARD TURN OFF TIME
1210
PRESTORED TURN ON OFFSET
1215
PRESTORED TURN OFF OFFSET
1220
RECEIVED TURN ON OFFSET
1225
RECEIVED TURN OFF OFFSET
1230
RECEIVED DIMMING PROFILE
1235
PRESTORED DIMMING PROFILE
1240

FIG. 22

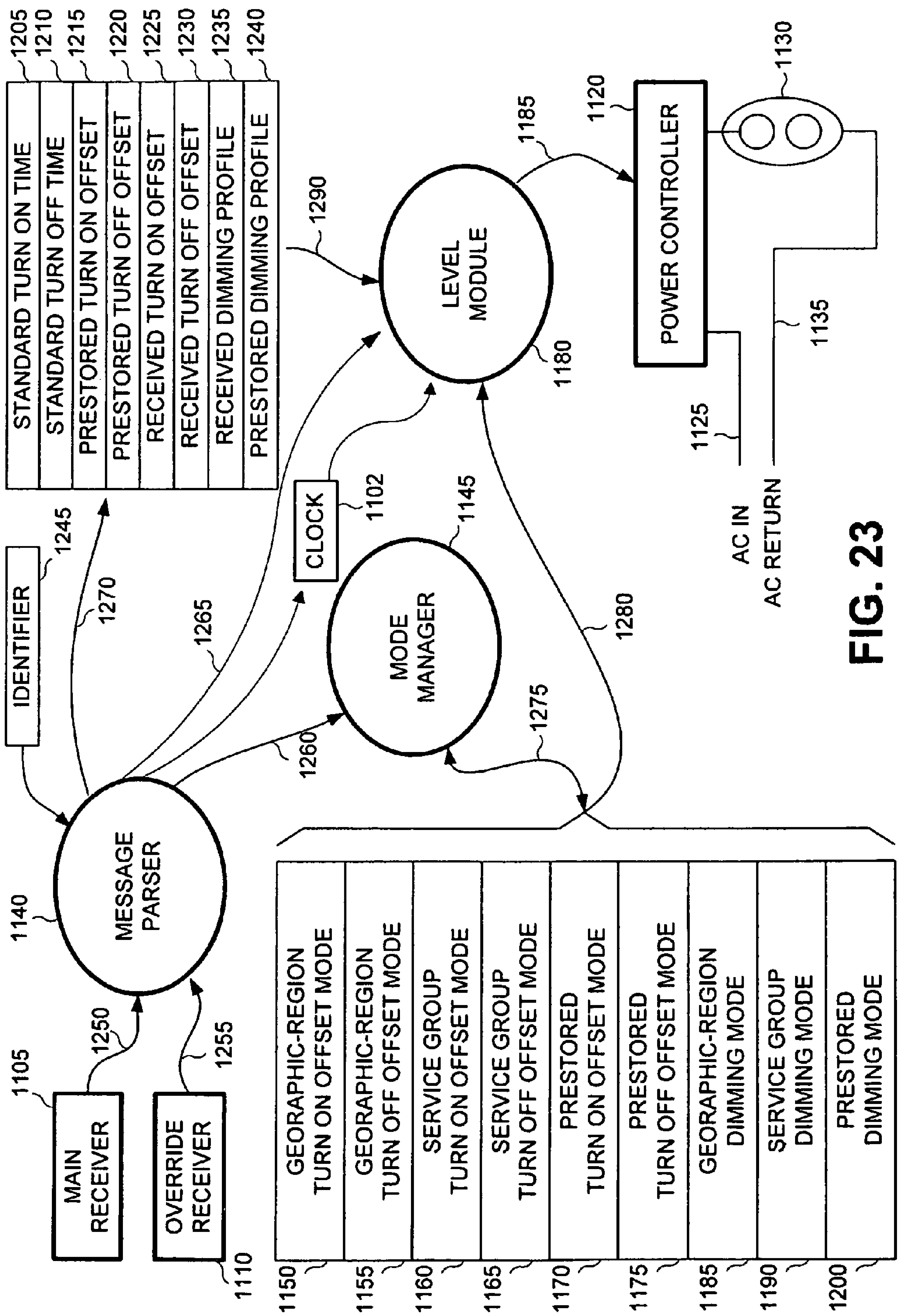

STANDARD TURN ON TIME
STANDARD TURN OFF TIME
PRESTORED TURN ON OFFSET
PRESTORED TURN OFF OFFSET
RECEIVED TURN ON OFFSET
RECEIVED TURN OFF OFFSET
RECEIVED DIMMING PROFILE
PRESTORED DIMMING PROFILE
1205
1210
1215
1220
1225
1230
1235
1240
1290
1185
1120
1130
LEVEL MODULE
POWER CONTROLLER
1180
1135
1125
AC IN
AC RETURN
IDENTIFIER
1245
1270
1265
CLOCK
1102
1145
MODE MANAGER
1280
1275
1260
MESSAGE PARSER
1140
1105
1250
1255
MAIN RECEIVER
OVERRIDE RECEIVER
1110
GEORAPHIC-REGION TURN ON OFFSET MODE
GEORAPHIC-REGION TURN OFF OFFSET MODE
SERVICE GROUP TURN ON OFFSET MODE
SERVICE GROUP TURN OFF OFFSET MODE
PRESTORED TURN ON OFFSET MODE
PRESTORED TURN OFF OFFSET MODE
GEORAPHIC-REGION DIMMING MODE
SERVICE GROUP DIMMING MODE
PRESTORED DIMMING MODE
1150
1155
1160
1165
1170
1175
1185
1190
1200

FIG. 23

METHOD AND APPARATUS FOR SYNCHRONOUS SINE WAVE DIMMING OF LUMINARIES

RELATED APPLICATIONS

The present application claims priority to U.S. provisional patent application No. 61/400,440, filed on Jul. 27, 2010 by Jack J'maev entitled "Method and Apparatus for Synchronous Sine Wave Dimming of Luminaries" which is incorporated herein by reference in its entirety; the present application also claims priority U.S. provisional patent application No. 61/456,304, filed on Nov. 3, 2010 by Jack J'maev entitled "Method and Apparatus for Synchronous Sine Wave Dimming of Luminaries" which is incorporated herein by reference in its entirety, to such extent as allowed by law.

BACKGROUND

Over the years, there has been a continuing need for variable output AC power sources. Application of such variable output AC power sources includes driving reactive loads. Some examples of such reactive loads include electric motors, ballasts for discharge-based lighting (e.g. high-pressure sodium vapor luminaries that may be used in street lighting) and other various types of applications. Because of the pressing need for a variable output AC power source, a wide range of solutions has been developed ranging from auto transformers to sophisticated pulse width modulated (PWM) power controllers. It is in this prior-art rich environment that the present method and apparatus is distinguished in terms of its ability to deliver substantially pure sinusoidal power to such reactive loads at higher levels of efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

Several alternative embodiments will hereinafter be described in conjunction with the appended drawings and figures, wherein like numerals denote like elements, and in which:

FIG. **1** is a pictorial illustration that depicts a prior art "H" bridge power controller;

FIG. **2** is a pictorial illustration of a classic prior art synchronous "buck" step-down converter;

FIG. **3** is a waveform diagram depicting prior art methods directed at a phenomenon known as simultaneous conduction;

FIG. **4** is a pictorial representation of a prior art AC buck down-converter which utilizes diodes in order to help reduce the dead time needed to preclude simultaneous conduction;

FIG. **5** is a timing diagram that depicts the control of switches across back-to-back diodes used in one form of a prior art AC buck down-converter;

FIG. **6** is a pictorial representation of a present art embodiment of an AC buck down-converter;

FIG. **7** is a pictorial representation of an input AC waveform and a resulting a AC waveform derived according to the present example method and embodiment of a buck down-converter;

FIGS. **8** and **9** are, respectively, a timing diagram and an operational diagram that depict the manner in which the present art controls the semiconductor switches included in the synchronous freewheel switch when the input voltage is greater than that at the common terminal in a three-terminal buck down-converter;

FIGS. **10** and **11** are, respectively, a timing diagram and a operational diagram that depict the manner in which the present art controls the semiconductor switches included in the synchronous freewheel switch when the input voltage is less than that at the common terminal in a three-terminal buck down-converter;

FIGS. **11**A and **11**B are, respectively, a pictorial diagram and a timing diagram that depicts the operation of one illustrative example method and apparatus when current is flowing in a positive direction through a buck inductor;

FIGS. **11**C and **11**D are, respectively, a pictorial diagram and a timing diagram that depicts the operation of one illustrative example method and apparatus when current is flowing in a negative direction through a buck inductor;

FIG. **12** is a pictorial diagram that depicts application of the present AC buck down-converter for reducing power used by luminaries (e.g. street lights);

FIG. **13** is a block diagram that depicts several example embodiments of a radio-directed luminary controller;

FIG. **14** is a flow diagram that depicts one example method for autonomous control of luminaries;

FIG. **14**A is a pictorial representation of various methods of geographical partitioning of one or more service regions;

FIG. **15** is a flow diagram that depicts one example method for identifying a data source;

FIG. **16** is a flow diagram that depicts one illustrative method for receiving a list of service groups;

FIG. **17** is a flow diagram that depicts one example method for determining a turn-on time for a luminary;

FIG. **18** is a flow diagram that depicts one example method for determining a turn-off time for a luminary;

FIG. **19** is a flow diagram that depicts an alternative method for radio directed luminary control;

FIG. **20** is a flow diagram that depicts one alternative example method that provides for dimming of luminaries;

FIG. **21** is a block diagram that depicts various alternative embodiments of a logic controller included in a luminary controller;

FIG. **22** is a block diagram that depicts alternative example embodiments of a luminary controller; and

FIG. **23** is a data flow diagram that depicts the operation of a processor-based luminary controller.

DETAILED DESCRIPTION

FIG. **1** is a pictorial illustration that depicts a prior art "H" bridge power controller. The "H" bridge power controller is amongst recent prior art enabled by high-performance semiconductor switching elements. Such switching elements include, but are not limited to MOSFETs (metal on silicon field effect transistors) and isolated gate bipolar-junction transistors (IGBTs). In the classic "H" bridge architecture, an AC source **10** is directed to a rectification circuit **20**. The rectification circuit **20** converts power from the alternating current source **10** into direct current (DC) voltage. Accordingly, this prior art method and apparatus develops a positive rail **25** and a ground rail **30**. Four switching devices, which in this illustrative example are depicted as MOSFETs, are controlled by a pulse width modulation signal having two phases. In the figure presented, phase A (**40**) and phase B (**50**) are used to alternatively switch two output nodes (output points **60** and **70**) from the positive rail **25** to the ground rail **30**. The output points are driven substantially 180 degrees out of phase one from the other. By controlling the pulse width over time, sine waves of different amplitudes may be generated at the output terminals **80**A and **80**B. It should immediately be appreciated that this configuration of prior art must actively create a sinusoidal waveform at its output by manipulating the pulse width at phase A (**40**) and phase B (**50**) so as to generate an output waveform in accordance with a desired amplitude and shape. Accordingly, this form of prior art requires extensive computational processing power. Another disadvantage with this form of prior art is that the H-Bridge requires four terminals in order to provide a variable output AC power source. Two terminals receive the source AC power and two terminals provide output AC power as generated by the waveform shaping, pulse width modulation process.

FIG. **2** is a pictorial illustration of a classic prior art synchronous "buck" step-down converter. In an ideal situation, the synchronous buck step-down converter **90** includes at least two switches. A first switch **100** is often referred to as the buck switch. A second switch **110** is often referred to as a freewheel switch. In this classic structure, an input source **120** may be either-DC or AC. Accordingly, this structure has often been used as a means for generating reduced voltage AC waveforms. If in fact the buck switch **100** and the freewheel switch **110** were perfect ideal switches, the control signal **130** for the buck switch **100** and the control signal **140** for the freewheel switch **110** would be complements of each other. Voltage feedback **150** could be used to control the duty cycle of the buck control signal **130** in order to control the output voltage **125** provided by the buck voltage step-down converter **90**. In many situations, however, the output voltage need only be a reduced version of the input source **120**. In these situations, the voltage feedback **150** is not necessary. Simply maintaining the buck control signal **130** at a constant duty cycle will allow the output voltage **125** to vary in accordance with the input waveform provided by the source **120**. It should be appreciated that the output waveform will be scaled in amplitude according to the duty cycle of the buck control signal **130**. Operation of this classic buck regulator is well known in the art and need not be further described here.

FIG. **3** is a waveform diagram depicting prior art methods directed at a phenomenon known as simultaneous conduction. Unfortunately, ideal switches don't seem to exist in the real world. Furthermore, process variations and other errors in the control circuitry depicted in FIG. **2** may cause the buck switch **100** and the freewheel switch **110** to be switched on contemporaneously. This situation would generally result in a catastrophic failure because the power from the source **120** is fed directly back via the common terminal **160** when the buck switch **100** and the freewheel switch **110** are both on at the same time. This is the classic case of "simultaneous conduction". As can be seen in FIG. **3**, the buck switch control signal **130** and the freewheel control signal **140** are complements of each other. In this illustration, the duty cycle of the buck switch control signal **130**, in this example, is substantially equal to 50 percent. As readily known in the prior art, as the duty cycle of the buck switch control signal **130** is increased, the duty cycle of the freewheel control signal **140** is proportionately decreased. In order to prevent simultaneous conduction, a shoot through signal **180** is typically developed in order to provide for a dead time **190**.

By using the shoot through signal **180** to qualify the buck switch control signal **130** and to also qualify the freewheel switch control signal **140**, a safe buck control signal **135** and a safe freewheel control signal **145** are developed. As is well known in the prior art, this dead time precludes simultaneous conduction by ensuring that the buck switch **100** and the freewheel switch **110** are not switched on at the same time. However, those skilled in the art will immediately recognize that this "dead time" results in a discontinuity of current flow in the buck inductor **102** depicted in FIG. **2**. And, those skilled in the art will also recognize that such discontinuity of current flow in the buck inductor **102** results in voltage spiking at node **107**, which is the worst possible place in the topology of this prior art in that it subjects semiconductor switches to high-voltage kick-back from the inductor. Such nigh voltages can result in catastrophic failure of semiconductor switches. Node **107** is the common node that connects the buck switch **100**, the freewheel switch **110** and the buck inductor **102** to each other.

FIG. **4** is a pictorial representation of a prior art AC buck down-converter which utilizes diodes in order to help reduce the dead time needed to preclude simultaneous conduction. In this prior art method and apparatus, two diodes **210** and **220** are placed "back-to-back", i.e. with their anodes connected to each other. The cathode of one diode **210** is connected to the buck switch **200** and to the buck inductor **205** (i.e. node **207**). This diode is referred to as the positive freewheel because it allows current to continue to flow through the buck inductor **205** when the buck switch **200** is turned off and the input voltage **235** is greater than the voltage at the common terminal **240**. The second diode **220**, referred to as the negative freewheel diode, is disposed such that its cathode is connected to the common terminal **240**. The negative freewheel diode conducts current from the buck inductor **205** back to the common terminal **240** when the buck switch is turned off and the input voltage **235** is less than the voltage at the common terminal **240**.

Two switches **215** and **225** are used to connect across one or the other of the diodes **210** and **220** based on the voltage of the input terminal **235** relative to the common terminal **240**. When the input voltage is greater than the common terminal **240** (**249**), then the switch **225** across diode **220** (the negative freewheel diode) is engaged. This allows freewheel current to bypass the negative freewheel diode **220** and flow through the positive freewheel diode **210** when the buck switch **200** is turned off. In a similar manner, when the input voltage at the input terminal **235** is less than the voltage at the common terminal **240** (**232**), the switch **215** across the positive freewheel diode **210** is engaged and the freewheel current bypasses the positive freewheel diode **210** and is then allowed to flow through the negative freewheel diode **220**. The problem with this prior art circuit is the ambiguity **230** associated with determining if the input voltage is less than or greater than the voltage at the common terminal **240**. During this period of ambiguity, if the wrong switch (**215** or **225**) is engaged, there is a potential for inducing a discontinuity in the current flow of the buck inductor **205**. This results in the usual high-voltage spike at node **207**. Those skilled in the are will appreciate that this high voltage spiking is caused by the back-driven electro-motive-force (EMF) stored in the buck inductor **205**. Such high voltage spiking can irreparably damage semiconductor switches which are often used in the position of the buck switch **200** and the diodes used to maintain freewheeling current in the inductor **205**.

FIG. **5** is a timing diagram that depicts the control of switches across back-to-back diodes used in one form of a prior art AC buck down-converter. As can be seen; two switching signals, switch N (SN) and switch P (SP), which are depicted as items **216** and **226** in FIGS. **4** and **5**, alternately enable switches **215** and **225** in order to enable freewheel current to flow through diode **210** or diode **220** based on the polarity of the input AC voltage at the input terminal **235** relative to the common terminal **240**. In order to compensate for the ambiguity **235** in determining the polarity of the AC signal, it is necessary to discontinue **260** the function of the buck switch **200** by allowing it to be enabled (i.e. turned on) during the period of ambiguity **230**. The freewheel switches are turned of during this time. This results in deformation and unwanted harmonics in the output waveform delivered to the output terminal **241** (in FIG. **4**).

FIG. **6** is a pictorial representation of a present art embodiment of an AC buck down-converter. Today, the shortcomings of prior art AC buck down-converter topologies have been overcome. In this example method and embodiment, semiconductor devices are used for bi-directional switching of current in both the buck switch position **300** and the freewheel position **305**. It should further be appreciated that the current state of the art embodies a synchronous freewheel mechanism. In this example method and embodiment, the buck switch **300** comprises two semiconductor switches, for example two MOSFETs. A first MOSFET **310** is disposed so as to receive the input AC waveform **320** at its drain terminal. The source of this first MOSFET **310** is electrically connected to a source terminal of a second MOSFET **315** that is also included in the buck switch **300**. The drain of this second MOSFET **315** comprises the output of the buck switch **300** and is connected to the buck inductor **360** and the freewheel switch **305**. In this example method and embodiment, buck control is accomplished by MOSFET gate drivers **320**, **325**. It should be appreciated that these gate drivers comprise "high-side" drivers and include high-voltage isolation between the buck switch **300** and a control circuit **335**. In one example embodiment, the signals to control the gate drivers **325** and **320** are substantially identical to each other in terms of timing. This causes both semiconductor switches **310** and **315** to be on of the same time. This results in bi-directional switching of the input current received from the AC source **320**.

In this example method and embodiment, the control circuit **335** operates relative (**337**) to the common terminal **340**. Power for the control circuit **335** is derived from the input AC waveform directed (**335**) to the control circuit. The AC input voltage **350** to the control circuit **335** also enables the control circuit to monitor the polarity of the input voltage AC waveform **320** at the input terminal **355** relative to the common terminal **340**. The current topology also includes a buck inductor **360**, the output of which is directed to an output terminal **365**. This example method and embodiment further comprises a synchronous freewheel switch **305** comprising a third MOSFET **370** and a fourth MOSFET **375**. Third and fourth gate drivers **380** and **385** are also "high-side", isolated drivers that are included in this example method and embodiment of the present art buck down-converter **390**.

FIG. **7** is a pictorial representation of an input AC waveform and a resulting a AC waveform derived according to the present example method and embodiment of a buck down-converter. It should be appreciated that the current method and embodiment enables substantially true replication of the AC waveform **370** present at the input terminal **355**, but at a reduced voltage level **380**. The output waveform **380** is reduced in voltage according to the duty cycle applied to the buck switch **300** of the present embodiment. This figure depicts only one example use case wherein the duty cycle applied to the buck switch **300** is substantially equal to 50 percent. It should be appreciated that the buck switch can be operated at any duty cycle and the claims appended hereto or not intended to be limited to any particular example application or operational case of the present method and embodiment.

FIGS. **8** and **9** are, respectively, a timing diagram and an operational diagram that depict the manner in which the present art controls the semiconductor switches included in the synchronous freewheel switch when the input voltage is greater than that at the common terminal in a three-terminal buck down-converter. The present method and apparatus are best understood by examining the timing diagram of the buck switch control signal **400** relative to a positive freewheel control signal **410** and a negative freewheel control signal **420**. The two semiconductor switches (e.g. MOSFETs) are disposed in a manner such that the source of the third semiconductor switch **370** is electrically connected to the source of the fourth semiconductor switch **375** and the drain of the third MOSFET **370** is electrically connected to the output of the buck switch **300** and to the buck inductor **360**. The fourth MOSFET **375** is disposed in a manner wherein the drain of the fourth MOSFET **375** is electrically connected to the common terminal **340**.

MOSFET are particularly useful to the present method and apparatus in that they included a parasitic diode within their structure. By connecting the two source terminals of the third and fourth MOSFETs **370**, **375**, the parasitic diodes in these devices are also placed "back-to-back", i.e. having their anodes electrically connected. Should other types of semiconductor switches be utilized for the synchronous freewheel switch **305**, external diodes would need to be provided. In operation, the synchronous freewheel switches **370** and **375** are both turned on when the buck switch **300** is turned off. When the AC input voltage is greater than the common terminal, the synchronous freewheel switch **305** to conducts current from the common terminal **340** through to the buck inductor **360** (path **430**). And because both freewheel switches **370** and **375** are turned on, there is significant reduction in power loss because the current, which ordinarily would flow through the parasitic diode (i.e a positive freewheel diode) of MOSFET **370**, avoids the diode voltage drop because the MOSFET **370** is itself turned on. This improves overall efficiency in the down-conversion process.

Commensurate with the turn-on and turn-off delays of the buck switch **300** and the synchronous freewheel switch **305**, the positive freewheel signal **410**, which controls MOSFET **370**, is turned off just prior to enabling the buck switch control signal **400**. At this point, the freewheel current **430** is allowed to flow through MOSFET **375** by virtue of the fact that MOSFET **375** remains turned on by the negative freewheel control signal **420**. The diode across MOSFET **370** continues to carry the current **430** just prior to the point where the buck switch control signal **400** is enabled. After the buck switch control signal **400** is turned off, the positive freewheel signal **410** is again turned on so as to bypass the diode drop of the positive freewheel diode (in MOSFET **370**). Accordingly, there is a shoot-through elimination period **415** just prior to enabling the buck switch and just after disabling the buck switch **416**. Current is then provided **440** to the buck inductor **360** by the buck switch **300**.

The negative free wheel switch **375**, which is controlled by the negative free wheel control signal **420** is then turned off just after the buck switch is turned on so as to preclude current **430** from the load entering the circuit from the common terminal **340** where it can interact with the current provided by the buck switch **300**. The negative free wheel switch **375** is turned back on just prior to turning off the buck switch in order to bypass the negative free wheel diode included in MOSFET **375** so that the buck inductor **360** does not experience any discontinuity in current flow. This results in bypass of the reverse-biased negative freewheel diode (in MOSFET **375**) just after and just before (**422**, **423**) the buck switch is turned on and off, respectively. This is part of the synchronous freewheel mechanism of the present art. By preventing current from the load, which is most probably reactive current that is not in phase with the current provided by the buck switch, from combining with the current provide with the buck switch **300**, the power factor of the load as perceived by the AC source **320** remains substantially similar to the inherent power factor exhibited by said load. But for turning off the switch across the negative freewheel diode included in the forth MOSFET **375**, the buck down-converter may adversely affect the power factor perceived by the AC source **320**. This is merely one advantage of the prior art depicted in FIG. **4**.

FIGS. **10** and **11** are, respectively, a timing diagram and a operational diagram that depict the manner in which the present art controls the semiconductor switches included in the synchronous freewheel switch when the input voltage is less than that at the common terminal in a three-terminal buck down-converter.

In this state of operation, the synchronous freewheel switches **370** and **375** are both turned on when the buck switch **300** is turned off. When the AC input voltage is less than that at the common terminal **340**, this allows the synchronous freewheel switch **305** to conduct current from the buck inductor **360** to the common terminal **340**. Again, because both freewheel switches **370** and **375** are turned on, there is significant reduction in power loss because the current, which ordinarily would flow through the parasitic diode (i.e a negative freewheel diode) of MOSFET **375**, avoids the diode voltage drop because the MOSFET **375** is itself turned on. This improves overall efficiency in the down-conversion process.

Commensurate with the turn-on and turn-off delays of the buck switch **300** and the synchronous freewheel switch **305**, the negative freewheel signal **420**, which controls MOSFET **375**, is turned off just prior to enabling the buck switch control signal **400**. At this point, the freewheel current **432** is allowed to flow through MOSFET **370** by virtue of the fact that MOSFET **370** remains turned on by the positive freewheel control signal **410**. The diode across MOSFET **375** continues to carry the current **432** just prior to the point where the buck switch control signal **400** is enabled. After the buck switch control signal **400** is turned off, the negative freewheel signal **420** is again turned on so as to bypass the diode drop of the negative freewheel diode (in MOSFET **375**). Accordingly, there is a shoot-through elimination period **422** just prior to enabling the buck switch and just after disabling the buck switch **423**. Current is then provided **442** to the buck inductor **360** by the buck switch **300**. It should be appreciated that this current is actually pulled back into the AC source **320** because the AC source **320** is in the negative portion of its waveform.

The positive free wheel switch **370**, which is controlled by the positive free wheel control signal **410** is then turned off just after the buck switch is turned on so as to preclude current **432** from the load entering the circuit from the common terminal **340** where it can interact with the current provided by the buck switch **300**. The positive free wheel switch **370** is turned back on just prior to turning off the buck switch in order to bypass the positive free wheel diode included in MOSFET **370** so that the buck inductor **360** does not experience any discontinuity in current flow. This results in bypass of the reverse-biased positive freewheel diode (in MOSFET **370**) just after and just before (**415**, **416**) the buck switch is turned on and off, respectively. This is part of the synchronous freewheel mechanism of the present art. Again, by preventing current from the load, which is most probably reactive current that is not in phase with the current provided by the buck switch, from combining with the current provide by the buck switch **300**, the power factor of the load as perceived by the AC source **320** remains substantially similar to the inherent power factor exhibited by said load. But for turning off the switch across the positive freewheel diode included in the forth MOSFET **370**, the buck down-converter may adversely affect the power factor perceived by the AC source **320**.

FIGS. **11**A through **11**D depicts an alternative example method and apparatus useful for providing a reduced voltage sine wave to a highly inductive or reactive load. Thus far, the method and apparatus described relied upon controlling the synchronous freewheel switches based on the voltage present at the input terminal in order to determine which freewheeling switch should be engaged in order to maintain constant current flow through the buck inductor. For extremely reactive loads, it is well understood in the art of the voltage and current may be drastically out of phase one from the other. This is represented by a value known as "power factor". When the power factor is at unity (i.e. "1"), and the current and voltage are precisely in phase with each other. However, as power factor decreases, the current flow through the buck inductor may lead or lag the voltage waveform present at the input terminal. Accordingly this alternative method and apparatus address the need to maintain continuous current flow in the buck inductor despite a leading or lagging current waveform relative to the voltage waveform presented to the input of the apparatus.

FIGS. **11**A and **11**B are, respectively, a pictorial diagram and a timing diagram that depicts the operation of one illustrative example method and apparatus when current is flowing in a positive direction through a buck inductor. For the sake of convention, a current will be considered positive when it is flowing into a component, for example the buck inductor **1500**. In the case where the load exhibits a very poor power factor, it becomes necessary not only to independently control the synchronous freewheel switches but to also independently control the buck switches. In this illustrative example method and apparatus, the synchronous freewheel comprises two synchronous freewheel switches identified as the positive freewheel "PF" **1520** and in the negative freewheel "NF" **1525**. This illustrative method and apparatus, the freewheel switches comprise MOSFET devices disposed in a manner in which the drain of the negative freewheel MOSFET switch **1525** is electrically common to the buck inductor **1500** and buck switch. The positive freewheel MOSFET switch **1520** is disposed in a manner such that its drain terminal is connected to the neutral terminal of the apparatus. The MOSFETs **1520**, **1525** forming the freewheel switch are dispose in a manner such that there source terminals are electrically common. This illustrative method and apparatus further comprise gate driving circuit **1530** and **1535** which enable control of the gate terminals of their respective MOSFETs. It should be appreciated that the scope of the claims appended hereto are not intended to be limited in scope to the use of MOSFET switches. Any type of switch may be used, however different types of switches may require the use of two back to back diodes as described earlier in this specification. As has already been pointed out, MOSFETs are a preferred switching device insofar as they include a parasitic diode within their structure and additional back to back diodes are not required as previously described.

In this example method and apparatus, the buck switch comprises two switching devices **1540** and **1545**. Unlike the earlier described method and apparatus, in this illustrative method and apparatus the two buck switches are controlled individually. Accordingly the buck switch comprises a positive buck switch "PB" **1540** and a negative buck switch "NB" **1545**. Accordingly, each buck switch is controlled by a gate drive circuit, depicted in the figure as **1550** and **1555**. In order to maintain constant current flow through the buck inductor **1500**, it becomes necessary to add an additional element to the apparatus and an additional step to the method supporting such apparatus. Mainly, an additional step includes sensing the direction of current flow in the buck inductor **1500**. Accordingly, this illustrative apparatus further includes a current sensor **1560** which provides current sensing **1565** for the controller **1570**. It should be appreciated that the structure of the buck switch in this alternative example method is analogous to the structure of the synchronous freewheel switch described above. In this illustrative example embodiment, the buck switch comprises the positive buck switch **1540** and a negative buck switch **1545** and each of these switches is disposed in parallel with an associated diode **1615** and **1620**. Accordingly, the positive buck diode **1620** is disposed with its cathode electrically common with the negative buck switch **1545** and is back-to-back with the negative buck diode **1615** wherein the negative buck diode **1615** is disposed in a manner such that its cathode is electrically common with the positive buck switch **1540**. Although the positive buck switch **1540** and the negative buck switch **1545** are depicted in the figure as MOSFETs, any suitable switch may be utilized, however positive and negative buck diodes (**1620**, **1615**) must then be supplied in addition to the switches. As noted numerous times throughout this specification MOSFETs are a preferred device because of the parasitic diode is included in their structure.

This alternative example method and apparatus are best understood through the teachings of the timing diagram (FIG. **11**B) that depicts the sequence of switching the synchronous freewheel switches and the buck switches in the case where current is flowing into the buck inductor **1500** from the source **1582** or from the load **1585**. In this figure, four control signals are depicted. These include a positive freewheel (PF) control signal **1601**, a negative freewheel (NF) control signal **1602**, a positive buck control signal **1603** and a negative buck control signal **1604**. For the sake of clarity, these signals are depicted as "active high". Considering the situation when the synchronous freewheel switches are both engaged, positive current **1510** flows through the buck inductor **1500** because both the negative freewheel switch **1525** in the positive freewheel switch **1520** are both engaged by means of NF **1602** and PF **1601** control signals. This is illustrated by the timing diagram at point **1600** and it should be appreciated that while both freewheel switches are engaged, both buck switches are turned off (i.e. control signals PB **1603** and NB **1604** are low) as depicted in the timing diagram. According to this illustrative method and apparatus, switching from the freewheel state to the buck state occurs in a particular manner based upon the direction of current flowing through the buck inductor **1500**. This current is flowing **1510** through the synchronous freewheel switches, the current must flow through the buck inductor **1500** because the buck switches are both turned off.

Transitioning to the buck state in this situation comprises a first step of disengaging **1605** the negative freewheel switch **1525**. When the negative freewheel switch **1525** is disengaged **1605**, it should be appreciated that current **1510** continues to flow through the buck inductor **1500** and is maintained by the negative freewheel diode **1610** which is disposed across the negative freewheel switch **1525** having its cathode electrically common with the buck switch and the inductor. Once the negative freewheel is disabled, it is now safe to engage **1630** the positive buck switch **1540**. This allows current **1505** to flow from the source **1580** into the buck inductor **1500** even though the negative buck switch **1615** is still turned off since the diode **1615** disposed across the negative buck switch **1545** allows the current to flow from the source **1580** into the inductor **1500**. Given that the current flow is now being carried by the buck switch in a positive direction **1505**, the positive freewheel switch **1520** is then disabled **1635**. At this point, the negative buck switch **1615** is engaged **1640**.

When transitioning from the buck state to the freewheel state in the case where positive current **1505** is flowing into the buck inductor **1500** from the source **1580**, the buck switch and freewheel switch elements are controlled in a symmetrical manner relative to the transition to the buck state from the freewheel state. As such, current flowing **1505** from the buck switch must be maintained in order to prevent discontinuous current flow through the buck inductor **1500**. Accordingly, the negative buck switch **1545** is turned off **1645**. Even though the negative buck switch **1545** is turned off, the diode **1615** disposed across the negative buck switch **1545** continues to allow current to flow from the source **1580** into the buck inductor **1500**. The positive freewheel switch **1520** is then turned on **1650**. This now enables positively flowing current **1510** to be directed into the buck inductor **1500**. However the freewheel current **1510** is not allowed back to the source **1580** because the negative buck switch **1545** is turned off and the current flow is prevented by the diode **1615** that is disposed across the negative buck switch **1545**. At this point, the positive buck switch **1540** is turned off **1660**. At this point, current is being carried by the diode **1610** disposed across the negative freewheel switch **1525** and by the positive freewheel switch **1520** by virtue of the fact that the positive freewheel switch **1520** has been turned on. Accordingly, the negative freewheel switch **1525** is then turned on **1655**, thus completing the transition from the buck state to the freewheel state when current is flowing into the inductor **1500**.

FIGS. **11**C and **11**D are, respectively, a pictorial diagram and a timing diagram that depicts the operation of one illustrative example method and apparatus when current is flowing in a negative direction through a buck inductor. In this illustrative example method, study of the timing diagram (FIG. **11**D) depicts the sequence for controlling the positive buck switch **1540**, the negative buck switch **1545**, the positive freewheel switch **1520** and the negative freewheel switch **1525**. For the sake of comprehension, it is best to examine the state of current flow during a freewheeling state depicted in the figure at point **1700**. At this point, both of the freewheel switches are enabled and both of the buck switches are disabled. According to this illustrative use case, freewheel current **1513** is flowing out of the inductor **1500** and down through the synchronous freewheel switches comprising the negative freewheel switch **1525** and the positive freewheel switch **1520**.

In this state, transitioning from the freewheel state to the buck state comprises a first step of disabling **1705** the positive freewheel switch **1540**. By disabling the positive freewheel switch **1520**, the freewheeling current **1513** is maintained because the negative freewheel switch **1525** is still turned on and current flow is maintained by the positive freewheel diode **1611** disposed across the positive freewheel switch **1520**. At this point, the negative buck switch **545** is enabled **1710**. This now allows current **1507** to start flowing from the buck inductor **1500** back to the source **1580**. It should be appreciated that turning on the negative buck switch **1545** allows the current to bypass the diode **1615** disposed across the negative buck switch and continue to be directed to the source **1580** by means of the diode **1620** disposed across the positive buck switch **1540**. Once this current path) is established, then the negative freewheel switch **1525** is disabled **1715**. In an additional step, once both the positive and negative freewheel switches are disabled, the positive buck switch **1540** is then enabled **1720**.

When transitioning from the buck state back to the freewheel state, the switches comprising the buck switch to the synchronous freewheel switch are controlled in a manner symmetrical to the manner in which the switches are controlled when passing from the freewheel state to the buck state. Accordingly, as negative current **1507** is flowing from the buck inductor **1500** back to the source **1580**, transitioning to the freewheel state comprises a first step of disabling **1725** the positive buck switch **1540**. This allows negative current **1507** to continue back to the source **1580** until the negative freewheel switch **1525** is enabled **1730**. At this point the negative freewheel switch **1525** allows current **1513** flowing from the inductor **1500** to pass through the freewheel switch and as should be appreciated to current **1530** is also carried by the diode **1611** disposed across the positive freewheel switch **1520**. At this point, the negative buck switch **1545** is disabled **1735**. Once both buck switches are off, the positive freewheel switch **1520** is then enabled **1740**.

In operation, the controller **1570** determines the direction of current flow by means of the current sensor **1562** disposed so as to enable determination of the direction of current flow in the buck inductor **1500**. It should be appreciated that the controller **1570** embodies the methods described herein for controlling the buck switches and the freewheel switches in a manner as described herein based upon the direction of current flowing in the buck inductor **1500**. It should be appreciated that the sequence described is best followed as rapidly in succession as allowed by the turn on and turn off delays associated with the positive and negative buck switches and positive and negative freewheel switches. Furthermore, in one illustrative alternative method and apparatus, determination of direction of current flow is accomplished as soon as practical relative to the transition from a buck state to a freewheel state and relative to the transition from a freewheel state to the buck state.

It should also be appreciated that the direction of current flow may change from positive to negative or negative to positive during a buck state or during a freewheel state. Accordingly, even though a particular sequence for controlling the individual buck switches and individual freewheel switches is utilized when entering either a buck state or a freewheel state, an alternative sequence for controlling the individual buck switches and individual freewheel switches is utilized in the event that the direction of current flow changes during the interval of time within a particular buck state or a particular freewheel state. In lay terms, even though the transition from a freewheel state to a buck state follows the sequence for positive current flow, the transition to the alternative state, according to this alternative example method and apparatus, will follow the sequence for transitioning based on negative current flow when such a reversal of current flow is detected during a particular buck state or during a particular freewheel state.

FIG. **12** is a pictorial diagram that depicts application of the present AC buck down-converter for reducing power used by luminaries (e.g. street lights). Dimming of street lights is not a new concept, however, the dimming of street lights, which are also referred to as luminaries, has thus far required complex electronic ballasts. The reason that complex electronic ballasts have been required is that prior art three-terminal dimming circuits impacted power factor of the luminaries because these prior art three-terminal devices were not capable of precluding reactive load currents from interacting with the current provided by the buck switch in these prior art technologies. As a result, more complicated topologies, such as the "H"-bridge of prior art that was discussed supra; have been used for dimming reactive loads, including luminaries. And, because the electronic dimming ballast for luminaries employed a four terminal device this required extensive retrofit of the luminary fixture. The costs of such retrofits could not be justified by the power savings that might otherwise be realized by deploying such dimming systems en masse.

Today, the synchronous buck down-converter described herein is able to provide a substantially pure sinusoidal waveforms to the load circuit with little to no perceptible difference in power factor. And, because the buck down-converter of the current method and apparatus is a three terminal device, a luminary **500** can be easily retrofitted. Many luminaries used throughout the world provide a three terminal receptacle **505**. The three terminal receptacle **505** is ordinarily used to accept a photocell. In the prior art, the photocell would enable power to a magnetic ballast in the luminary **500** when the ambient light levels fell below a preset threshold. Hence, the luminary would "turn-on" sometime near sunset and "turn-off" sometime near sunrise. In one example of the present method and apparatus, a radio-directed luminary controller **510** is used to replace the photocell. It should be appreciated that there are many different applications of a three terminal AC buck down-converter and the claims appended hereto are not intended to be limited to a simple application such as luminary control.

There are many shortcomings that are inherent in the use of photocells for controlling when a luminary is turned on and when it is turned off. For example, the photocell may react to atmospheric conditions such as heavy fog and allow the luminary to remain on even though the sun had long since breached the horizon. Also, of all things, the photocell structure can be obscured by bird droppings or other debris that may be deposited through adverse weather conditions. These are just two examples of degraded performance of such photocells that has caused many municipalities, states and private operators of luminaries to replace a photocell whenever the light in the fixture is replaced.

The use of radio control has seen some application in luminary control. However, these systems have still been limited to turning on and turning off the luminary at particular times. In these prior art methods, radio directives are received from a central control station and are used to direct the luminary to turn on and turn off at specific times. In these prior art systems, the central control system determines when the luminary should be turned on and when it should be turned off. Then, specific turn-on and turn-off commands are directed to the luminary. There is no autonomous control resident in each of the luminaries and if the central control station goes down, the luminaries must again revert to photocell control.

In some systems, the radio-directed luminary controller receives a time beacon and then uses a photocell to turn-on the luminary, but turns the luminary off later at night by means of a simple timer. For example, one prior art method turns on the luminary at sunset based on a photocell signal. However, because the luminary controller is cognizant of the time, it shuts the luminary off at a pre-established time which is programmed into the radio-directed luminary controller prior to, contemporaneous with or after its installation on the luminary fixture.

FIG. **13** is a block diagram that depicts several example embodiments of a radio-directed luminary controller. According to one method and apparatus, a radio-directed luminary controller **510** includes a receiver **520** which provides an input interface for an antenna **515**. In one alternative embodiment, an antenna **515** is also included in the radio-directed luminary controller **510**. In one example embodiment of the present method and apparatus, a logic-controller **525** is further included in the radio-directed luminary controller **510**. In one example embodiment, the radio-directed luminary controller **510** further includes a power controller **530**. In one preferred embodiment, the power controller **510** comprises a buck down-converter with a synchronous freewheel switch of the present method and apparatus as described herein. In yet another alternative embodiment, the power controller **510** comprises an on-off switch for simply turning the luminary on and off.

In operation, the logic controller **525** and the receiver **520** are both powered by the power controller **530**. The power controller **530** receives electrical power from a three-blade (**560**), twist lock plug **535**, which is included in one example embodiment of the present method and apparatus. It should be noted that power is obtained from the luminary fixture **500** when the twist lock plug **535** is mated with the receptacle **505** included in the luminary fixture **500** for the purpose of accepting a photocell or other controller. Power from the luminary fixture, according to one illustrative use case, comprises 120 volt AC power. In this case, the power controller **530** receives AC neutral **545** and AC phase A **540** from the twist lock plug **535** when said plug is installed in the receptacle **505**. In another illustrative use case, the luminary fixture provides a first phase of AC power (phase A **540**) and a second phase of AC power (phase B **545**). This is a common use scenario when the luminary fixture is wired for 220 volt AC operation in regions of the world where a single phase provide 120 volts relative to neutral. It should be appreciate that in those regions of the world where 220 volts is the normal utility voltage, a single phase provides 220 volts relative to neutral.

When commanded by the logic controller **525**, the power controller **530** directs AC voltage received as a first phase **540** to the luminary using an output blade (or terminal) **550** included in the twist lock plug **535**. It should be appreciated that in those embodiments that include a simple AC switch as the power controller **530**, the luminary **500** will not be dimmed but will only be turned-on or turned-off by the present method an apparatus. In those embodiments that include the buck down-converter in the power controller **530**, the output voltage provided **550** to the luminary will vary according to pulse width modulation duty cycle commands received by the power controller **530** from the logic controller **525**.

FIG. **14** is a flow diagram that depicts one example method for autonomous control of luminaries. In this illustrative method, a radio-directed luminary controller **510** uses a receiver **520** included therein to identify a data source (step **570**). In this example method; several transmitting stations are used to disseminate information that is used by the luminary controller **510** in order to turn on, turn off and to optionally dim the luminary in order to reduce power consumption.

Once a data source is identified, the luminary controller **510** then receives a time beacon (step **575**). According to one illustrative method and embodiment thereof, a luminary controller **510** will then synchronize an internal clock to the received time beacon (step **580**). Having accomplished these steps, the luminary controller **510** is then able to turn on, turn off or optionally dim the luminary based on time as prescribed by several other types of information received from the data source or from information that has been programmed into the luminary controller **510** either prior to, contemporaneous with or after the installation of the controller onto a luminary fixture **500**.

In one illustrative method, the luminary controller **510** determines a turn-on time (step **585**). Once the internal time clock provides a time reading that is substantially equal to, or in one alternative method is greater than or in yet another alternative embodiment is greater than or equal to the determined turn-on time (step **590**), then the luminary controller **510** commands the power controller **530** to apply power to the luminary (step **595**). Also in this illustrative method, the luminary controller **510** determines a turn-off time (step **600**). Once the internal time clock provides a time reading that is substantially equal to, or in one alternative method is greater than or in yet another alternative method is greater than or equal to the determined turn-off time (step **605**), then the luminary controller **510** commands the power controller **530** to deprive the luminary of electrical power (step **610**).

In yet another illustrative method, the luminary controller **510** receives a dimming profile (step **615**). This dimming profile, according to this illustrative method, provides dimming levels for various intervals of time during which the luminary may operate. Accordingly, a luminary controller **510** embodying this illustrative method applies the dimming profile (step **620**) according to the time maintained in the internal clock which was synchronized to a time beacon in step **580**.

FIG. **14**A is a pictorial representation of various methods of geographical partitioning of one or more service regions. It should be appreciate that, although the luminary controller **510** and the methods for luminary control described herein are intended to operate autonomously, there is still a need for the luminary controller **510** to obtain information in order to control luminary operation. According to various alternative methods, as described herein, a geographical region may be within the service region of one or more data sources (e.g. radio stations). Referring now to FIG. **14**A, geographical region "A" (**770**) is able to receive signals from two data sources, in this illustrative example these are transmitter **750** and transmitter **760**. The substantially circular patterns in the figure are meant to depict the coverage regions of various radio stations. It should also be noted that a particular radio station may not necessarily offer a substantially circular coverage region. In this example, transmitter **760** uses a directional antenna such that the service region it provides lies to one side of the stations and overlaps portions of the region serviced by transmitter **750**.

FIG. **15** is a flow diagram that depicts one example method for identifying a data source. A particular luminary controller may be geographically situated in a region that is serviced by only one data source. As discussed above with reference to FIG. **14**A, a particular luminary controller located in region A **770** may need to select a data source from one of two or more data sources (e.g. the transmitters described above). In one illustrative alternative method, a luminary controller **570** identifies a data source (step **570**) by first tuning to a radio frequency based on a' priori information (step **625**). It should be appreciate that tuning to an a' priori radio signal is an optional step. For example, in one illustrative use case, a luminary controller is pre-programmed with a data source identifier either prior to, contemporaneously with or after installation of the controller on the luminary **500**. In one alternative method, the data source identifier comprises at least one of a frequency code identifier, a frequency specified in hertz, and a frequency synthesizer coefficient. Those skilled in the art will be able to ascertain that a frequency code identifier or a frequency specification in hertz must be correlated to a frequency synthesizer coefficient, which is then directed to a frequency synthesizer in the receiver **520** included in the luminary controller **510**. Once the frequency synthesizer in the receiver **520** is seeded with the frequency coefficient, the receiver **520** is able to receive data from a transmitter transmitting on a particular frequency. Although the above example of selecting a receiver frequency is one exemplary method, the example set forth above is not intended to limit the scope of the claims appended hereto.

Once the frequency for reception has been selected, the luminary controller **510** determines if there is a data stream available from the radio station broadcasting on the selected frequency. If there is no perceptible data stream, the receiver must be tuned to a different frequency (step **645**) until a radio station that is broadcasting a perceptible data stream is found (step **630**). Once a perceptible data stream is received from a data source (i.e. radio station), the luminary controller **510** receives a list of service groups (step **635**). In other words, the luminary controller **510** must determine if a selected radio station is the data source which is providing information for the geographical region within which the luminary controller **510** is physically situated or is providing information for a luminary service group. If the luminary controller **510** finds its service group in the received listing, then that radio station is selected for subsequent use (i.e. it becomes the identified data source). Otherwise (step **640**), a different frequency is selected (step **645**) and the process is repeated until a data source (i.e. radio station) servicing the service group of a particular luminary controller is found.

FIG. **16** is a flow diagram that depicts one illustrative method for receiving a list of service groups. Briefly returning to FIG. **14**A, it should be appreciate that a service group includes at least one of a geographic region and an identifier of a group of luminaries. Furthermore, a geographic region, in one alternative method, is sub-divided into smaller regions. For example, region C **780** is itself divided into sub-regions C**1** through C**5**, inclusive. In at least one alternative example method, a service group comprises a geographic region (step **650**). In yet another illustrative method, the geographic region comprises a region having a substantially uniform climactic character, e.g. a "micro-climate" region (step **660**). It is important to appreciate that in those cases where the climactic character within a region is substantially uniform, certain atmospheric conditions will be similar across the region and, according to at least one illustrative alternative method, a dimming profile is established based on such atmospheric conditions.

FIG. **16** further depicts that a service group, according to one alternative method, comprises a luminary group (step **655**). A luminary group, according to this example method, comprises at least one of a luminary operated by a particular municipal or government entity (step **665**), a luminary operated by a private entity (step **670**) and a specifically identifiable group of luminaries (step **675**).

When a luminary controller **510** embodies the methods herein described, it should be noted that such a luminary controller **510** is typically configured with an identifier that is used to identify that luminary controller as part of a service group including at least one of said municipal identifier, government entity identifier, private operator identifier and specific luminary group identifier. Configuration of the luminary controller, according to various alternative methods, is accomplished prior to, contemporaneously with or after installation of the luminary controller on the luminary fixture **500**. According to one variation of the present method, a luminary controller receives a list of service groups from a particular data source. If that list includes the service group identifier seeded into the luminary controller during configuration, then that luminary controller will use the data source as it's "identified data source" (step **570**).

FIG. **17** is a flow diagram that depicts one example method for determining a turn-on time for a luminary. According to this alternative example method, determining a turn-on time (step **585**) comprises receiving a standard turn-on time (step **680**). In one alternative method, determining the turn-on time further comprises receiving a turn-on offset (step **690**) and applying the turn-on offset to the standard turn-on time in order to determine a turn-on time for the luminary (step **695**). In one alternative method, receiving a standard turn-on time comprises receiving the time at which sunset will occur (step **685**). In one alternative method, the time at which sunset occurs is received specifically for the location of the luminary, for example for the geographic region within which the luminary is situated. In yet another example method, the time at which sunset occurs is received by the luminary, but the received time of sunset specifies the time at which sunset occurs at the location of the data source (e.g. at the transmitter location).

According to various alternative example methods, the step of receiving a turn-on offset is accomplished in one of several ways including, but not limited to at least one receiving a turn-on offset for a geographic region (step **700**) (e.g. a micro-climate region), receiving a turn-on offset for a luminary service group (step **705**) and retrieving a pre-stored turn-on offset (step **710**). In the case where a turn-on offset is received for a geographic region, one example method provides for receiving by means of a receiver **520** included in the luminary controller **510** an offset value from the identified data source for that particular region in which the luminary is situated. In the case where a turn-on offset is received for a service group, this alternative method provides for receiving by means of a receiver **520** included in the luminary controller **510** an offset value for a particular group of luminaries. As already described, a particular group of luminaries includes a group identified by at least one of a municipality identifier, a government entity identifier, a specific luminary group identifier and a private operator identifier. In the case where a turn-on offset is a pre-stored value, this value is seeded in the luminary controller **510** when it is configured either prior to, contemporaneous with or after the luminary controller **510** is installed on the luminary fixture **500**.

FIG. **18** is a flow diagram that depicts one example method for determining a turn-off time for a luminary. According to this alternative example method, determining a turn-off time (step **600**) comprises receiving a standard turn-off time (step **715**). In one alternative method, determining the turn-off time further comprises receiving a turn-off offset (step **725**) and applying the turn-off offset to the standard turn-off time in order to determine a turn-off time for the luminary (step **730**). In one alternative method, receiving a standard turn-off time comprises receiving the time at which sunrise will occur (step **720**). In one alternative method, the time at which sunrise occurs is received specifically for the location of the luminary, for example for the geographic region within which the luminary is situated. In yet another example method, the time at which sunrise occurs is received by the luminary, but the received time of sunrise specifies the time at which sunrise occurs at the location of the data source (e.g. at the transmitter location).

According to various alternative example methods, the step of receiving a turn-off offset is accomplished in one of several ways including, but not limited to at least one of receiving a turn-off offset for a geographic region (step **735**) (e.g. a micro-climate region), receiving a turn-off offset for a luminary service group (step **740**) and retrieving a pre-stored turn-off offset (step **745**). In the case where a turn-off offset is received for a geographic region, one example method provides for receiving by means of a receiver **520** included in the luminary controller **510** an offset value from the identified data source for that particular region in which the luminary is situated. In the case where a turn-off offset is received for a service group, this alternative method provides for receiving by means of a receiver **520** included in the luminary controller **510** an offset value for a particular group of luminaries. As already described, a particular group of luminaries includes a group identified by at least one of a municipality identifier, a government entity identifier, a specific luminary group identifier and a private operator identifier. In the case where a turn-off offset is a pre-stored value, this value is seeded in the luminary controller **510** when it is configured either prior to, contemporaneous with or after the luminary controller **510** is installed on the luminary fixture **500**.

FIG. **19** is a flow diagram that depicts an alternative method for radio directed luminary control. In this alternative illustrative method, the present method further comprises receiving a turn-off offset directive (step **780**). In one alternative method, receiving a turn-off offset directive is accomplished by receiving a "use geographic-region turn-off offset" directive (step **785**). In yet another alternative example method, receiving a turn-off offset directive comprises receiving a "use service group turn-off offset" directive (step **790**). An in yet another alternative example method, receiving a turn-off offset directive comprises receiving a "use pre-stored turn-off offset" directive (step **795**).

Once a luminary controller **510** is installed on a luminary and in service, the operator of the luminary may need to reconfigure the luminary controller as to what type of offset is used for determining an offset time in conjunction with the standard turn-off time received (step **715**) by the luminary controller **510**. Accordingly, a luminary controller **510** will utilize a particular type of turn-off offset after it perceives such a directive.

It should be appreciated that such directives, according to these illustrative methods, are received by means of a receiver **510** included in the luminary controller **510** and the luminary controller will use the type of turn-off offset specified in the last turn-off offset directive received. In those cases where a "use pre-stored" offset directive is received, the luminary controller will simply use a pre-stored turn-off offset in order to determine the turn-off time. Otherwise, the luminary controller **510** will use at least one of a geographic region turn-off offset and a service group turn-off offset based on the latest turn-off offset directive received by the luminary controller **510** by means of the receiver **520** included therein.

FIG. **19** further depicts that in yet another alternative method for radio directed luminary control, the present method further comprises receiving a turn-on offset directive (step **800**). In one alternative method, receiving a turn-on offset directive is accomplished by receiving a "use geographic-region turn-on offset" directive (step **785**). In yet another alternative example method, receiving a turn-on offset directive comprises receiving a "use service group turn-on offset" directive (step **790**). And in yet another alternative example method, receiving a turn-on offset directive comprises receiving a "use pre-stored turn-on offset" directive (step **795**).

Once a luminary controller **510** is installed on a luminary and in service, the operator of the luminary may need to reconfigure the luminary controller as to what type of offset is used for determining an offset time in conjunction with the standard turn-on time received (step **680**) by the luminary controller **510**. Accordingly, a luminary controller **510** will utilize a particular type of turn-on offset after it perceives such a directive.

It should be appreciated that such directives, according to these illustrative methods, are received by means of a receiver **510** included in the luminary controller **510** and the luminary controller will use the type of turn-on offset specified in the last turn-on offset directive received. In those cases where a "use pre-stored" offset directive is received, the luminary controller will simply use a pre-stored turn-on offset in order to determine the turn-on time. Otherwise, the luminary controller **510** will use at least one of a geographic region turn-on offset and a service group turn-on offset based on the latest turn-on offset directive received by the luminary controller **510** by means of the receiver **520** included therein.

FIG. **19** further depicts that one alternative method for controlling a luminary controller further comprises receiving an override command (step **805**) and then executing that override command (step **810**). In certain situations, power to a luminary needs to be controlled either to support law enforcement activities or in response to exigent circumstances. In such cases, override commands are received by and acted upon by a radio-directed luminary controller **510**. For example, in one alternative method, the luminary controller **510** receives a turn-on command (step **815**). This may be utilized by law enforcement in order to override a dimmed luminary disposed near a crime scene. The converse may also be required. Law enforcement may need to turn off luminaries in order to cloak their activities from suspects not yet apprehended. In such cases, the luminary controller **510** will, according to another alternative method, receive a turn-off command (step **820**) and preclude power from reaching the lighting elements.

Exigent circumstances, such as power brown-outs, may require power to luminaries to be reduced so as to ease demand upon the power grid. Accordingly, an alternative illustrative method provides for receiving a dim command (step **822**) in the luminary and then causing the luminary to be dimmed in response to such an override command. It should be appreciated that such override commands, according to one alternative method, are received by means of a separate command receiver, for example a short range radio frequency (RF) receiver or an infrared pattern detector. In such alternative methods, short range transmitters (either RF or infrared) are used to convey override command to luminaries within range of such short range communications.

FIG. **20** is a flow diagram that depicts one alternative example method that provides for dimming of luminaries. According to this illustrative example method, a luminary controller receives a dimming profile (step **615**). A luminary controller, according to one alternative method, receives a dimming profile for a geographic region (step **825**). A geographic region, in one alternative method comprises a microclimate as described supra. In yet another alternative method, a luminary controller receives a dimming profile for a luminary service group (step **830**). An in yet another alternative example method, the luminary controller receives a dimming profile which is stored for future use. It should be appreciated that in the case where a dimming profile is received for a geographic region or for a luminary service group, the luminary controller will typically receive varying dimming profiles on some periodic basis, (e.g. daily, weekly, monthly or the like). Where a luminary controller receives a dimming profile which it stores for future use, such a dimming profile is typically not changed dynamically. However, there maybe several such pre-stored dimming profiles that may be stored in the luminary controller. It should be appreciated that a dimming profile, according to several alternative example methods, includes an enumeration of dimming levels versus time intervals. For example, dimming levels may be specified for hourly intervals, quarter-hour intervals and the like. It should be appreciated that these illustrative examples are meant to clarify the method of receiving a dimming profile and that any time interval can be used. Accordingly, the claims appended hereto are not intended to be limited to any particular example time intervals herein disclosed.

FIG. **20** further depicts that; according to yet another alternative example method, a luminary controller **510** further receives a dimming directive. According to one illustrative method, receiving a dimming directive comprises receiving a "use geographic dimming profile" directive (step **840**). In this case, the luminary controller **510** will dim the luminary **500** under its control based on a dimming profile transmitted by the identified data source for the particular region within which the luminary (and its controller **510**) are situated. In yet another illustrative alternative method, the luminary controller receives a "use service group dimming profile" directive (step **845**). In this case, the identified data source will transmit a dimming profile for a particular group of luminaries (e.g. by municipal identifier, by government entity identifier, by private operator identifier, or by specific luminary group identifier). In this alternative method, operators of specific luminaries are able to broadcast a new dimming profile that is stored by the luminary controller **510** and used as the basis for dimming. In yet another alternative example method, a luminary controller receives a dimming directive comprising a "use pre-stored dimming profile" directive (step **847**). In such case, the luminary controller **510** uses a dimming profile that was stored within the controller either prior to, contemporaneous with, or after the luminary controller **510** is installed on the luminary fixture **500**. In yet another illustrative method, receiving a dimming directive **835** comprises receiving a "disabled dimming" directive (step **849**).

FIG. **21** is a block diagram that depicts various alternative embodiments of a logic controller included in a luminary controller. According to one example embodiment, the logic controller **525** of FIG. **13** comprises a state machine **900** and a clock **905**. As a state machine **900** operates, the state machine **900** receives information from the receiver **520** included in the luminary controller **510**. The state machine **900** is configured to recognize various types of information that it receives from the receiver **520**. In one example embodiment, the state machine **900** recognizes a time message. When the state machine **900** recognizes a time message, the state machine extracts a time value from the time message and loads the time value into the clock **905**. The clock **905** operates to maintain a current time of day. It should be appreciated that the clock **905**, according to various alternative example embodiments, maintains time in the various formats. For example, the clock **905** maintains a current time of day in formats including a local time, a universal time coordinated and a system time.

In one example embodiment, the state machine **900** receives an identifier **901** in order to determine a data source from which the receiver **520** will receive information. In this example embodiment, the identifier **901** comprises at least one of a geographic identifier, a sub-geographic identifier, a municipality identifier, a government entity identifier, a private operator identifier, and a specific luminary group identifier. Accordingly, the state machine **900** first directs the receiver **520** to receive information on a particular radio frequency. The state machine **910** interrogates the receiver **520** in order to determine if the radio station on that particular radio frequency is transmitting a data stream recognizable by the state machine **900**. In the event that a data stream is present on the radio frequency to which the receiver **520** is tuned to, then the state machine **900** begins receiving information from the receiver **520**. Otherwise, the state machine **900**, directs the receiver **520** to tune to a different radio frequency. The state machine **900** will continue the process of directing the receiver **520** to a different frequency until the state machine **900** determines that the receiver **520** is receiving a data stream from a radio station at a particular frequency as specified to the receiver **520** by the state machine **900**.

As the state machine **900** receives information from the receiver **520**, the state machine **900**, according to one alternative example embodiment, receives a list of service groups from the receiver **520**. According to this example alternative embodiment, the state machine **900** will compare the identifier **901** to identifiers included in the list of service groups that the state machine **900** obtains from the receiver **520**. In the event that a successful comparison is made by the state machine **900**, the state machine **900** will continue to receive information from the receiver **520** using the current frequency programmed into the receiver **520** by the state machine **900**. Otherwise, the state machine **900** will direct the receiver **520** to a different frequency in order to again search for a data stream. This process, according to this alternative example embodiment, continues as the state machine **900** obtains various lists of service groups as transmitted by various radio stations that are transmitting a perceptible data stream and selected by the receiver **520** at various frequencies, said frequencies being specified by the state machine **900**.

As the state machine continues to operate, according to one alternative example embodiment, the state machine **900** is configured to receive a standard turn-on time from the receiver **520**. When the state machine **900** receives a standard turn-on time from the receiver **520**, the state machine **900** stores a standard turn-on time in a standard turn-on time register **955** included in the logic controller **525**. According to yet another alternative example embodiment, the state machine **900** is configured to receive a standard turn-off time from the receiver **520**. When the state machine **900** receives a standard turn-off time from the receiver **520**, the state machine **900** stores the standard turn-off time in a standard turn-off time register **960** included in the logic controller **525**.

In one alternative example embodiment, the logic controller **525** further includes one or more mode indicators that can be set and read by the state machine **900**. According to various alternative example embodiments, said mode indicators included at least one of a "use geographic-region turn-on offset" mode indicator **910**, a "use geographic-region turn-off offset" mode indicator **915**, a "use service group turn-on offset" mode indicator **920**, a "use service group turn-off offset" mode indicator **925**, a "use prestored turn-on offset" mode indicator **930**, a "use prestored turn-off offset" mode indicator **935**, a "use geographic-region dimming profile" mode indicator **940**, a "use service group dimming profile" mode indicator **945**, and a "use prestored dimming profile" mode indicator **950**.

FIG. **21** further illustrates that, according to various alternative example embodiments, the state machine **900** is configured to receive information comprising mode-switching directives. It should be appreciated that the state machine **900** includes a parser that enabled the state machine **900** to determine the type of mode-switching directive received. According to one alternative example embodiment, the state machine **900** receives from the receiver **520** mode-switching directives comprising at least one of a turn-off offset directive and turn-on offset directive. According to yet another alternative example embodiment, the state machine **900** receives a dimming directive from the receiver **520**.

The state machine **900** responds to various turn-off offset directives including, but not limited to at least one of a "use geographic-region turn-off offset" directive, a "use service group turn-off offset" directive, and a "use prestored turn-off offset" directive. In the case where the state machine **900** receives a "use geographic-region turn-off offset" directive, the state machine **900** responds by setting the "use geographic-region turn-off offset" mode indicator **910**. The state machine then clears the "use service group turn-off offset" mode indicator **925** and the "use prestored turn-off offset" mode indicator **935**. In the case where the state machine **900** receives a "use service group turn-off offset" directive, the state machine **900** responds by setting the "use service group turn-off offset" mode indicator **925**. The state machine then clears the "use geographic-region turn-off offset" mode indicator **915** and the "use prestored turn-off offset" mode indicator **935**. In the case where the state machine **900** receives a "use prestored turn-off offset" directive, the state machine **900** responds by setting the "use prestored turn-off offset" mode indicator **935**. The state machine then clears the "use geographic-region turn-off offset" mode indicator **915** and the "use service group turn-off offset" mode indicator **925**.

The state machine **900** responds to various turn-on offset directives including, but not limited to at least one of a "use geographic-region turn-on offset" directive, a "use service group turn-on offset" directive, and a "use prestored turn-on offset" directive. In the case where the state machine **900** receives a "use geographic-region turn-on offset" directive, the state machine **900** responds by setting the "use geographic-region turn-on offset" mode indicator **910**. The state machine then clears the "use service group turn-on offset" mode indicator **920** and the "use prestored turn-on offset" mode indicator **930**. In the case where the state machine **900** receives a "use service group turn-on offset" directive, the state machine **900** responds by setting the "use service group turn-on offset" mode indicator **920**. The state machine then clears the "use geographic-region turn-on offset" mode indicator **910** and the "use prestored turn-on offset" mode indicator **930**. In the case where the state machine **900** receives a "use prestored turn-on offset" directive, the state machine **900** responds by setting the "use prestored turn-on offset" mode indicator **930**. The state machine then clears the "use geographic-region turn-on offset" mode indicator **910** and the "use service group turn-on offset" mode indicator **920**.

The state machine **900** responds to various dimming directives including, but not limited to at least one of a "use geographic-region dimming profile" directive, a "use service group dimming profile" directive, a "use prestored dimming profile" directive and a "disable dimming" directive. In the case where the state machine **900** receives a "use geographic-region dimming profile" directive, the state machine **900** responds by setting the "use geographic-region dimming profile" mode indicator **940**. The state machine then clears the "use service group dimming profile" mode indicator **945** and the "use prestored dimming profile" mode indicator **950**. In the case where the state machine **900** receives a "use service group dimming profile" directive, the state machine **900** responds by setting the "use service group dimming profile" mode indicator **945**. The state machine then clears the "use geographic-region dimming profile" mode indicator **940** and the "use prestored dimming profile" mode indicator **950**. In the case where the state machine **900** receives a "use prestored dimming profile" directive, the state machine **900** responds by setting the "use prestored dimming profile" mode indicator **950**. The state machine then clears the "use geographic-region dimming profile" mode indicator **940** and the "use service group dimming profile" mode indicator **945**. In the case where the state machine **900** receives a "disable dimming" directive, the state machine **900** clears the "use geographic-region dimming profile" mode indicator **940**, the "use service group dimming profile" mode indicator **945**, and the "use prestored dimming profile" mode indicator **950**.

In one example alternative embodiment, the logic controller **525** includes at least one of a prestored turn-off offset register **975** and a prestored turn-on offset register **965**. In one alternative example embodiment, when the state machine **900** receives a static turn-off offset time from the receiver **520**, then the state machine **900** stores the static turn-off offset time in the prestored turn-off offset register **975**. In yet another alternative example embodiment, when the state machine **900** receives a static turn-on offset time from the receiver **520**, then the state machine **900** stores the static turn-on offset time in the prestored turn-on offset register **975**.

In one alternative example embodiment, the state machine **900** is configured to receive a turn-on offset value including at least one of a geographic-region turn-on offset and a service group turn-on offset. According to this alternative example embodiment, the state machine **900** determines the type of turn-on offset that should be used based on the "use geographic-region turn-on offset" mode indicator **910** and the "use service group turn-on offset" mode indicator **920**. When the "use geographic-region turn-on offset" mode indicator **910** is set, state machine **900** will ignore service group turn-on offset values that are received from the receiver **520** and will store a geographic-region turn-on offset value received from the receiver **520** in a stored turn-on offset register **970** included in this example alternative embodiment of a logic controller **525**. It should be appreciated that the state machine will select a geographic-region turn-on offset value from information received by the receiver **520** and selecting a geographic-region turn-on offset value according to the identifier **901**, which in this example embodiment comprises a geographic region identifier. When the "use service group turn-on offset" mode indicator **920** is set, state machine **900** will ignore geographic-region turn-on offset values that are received from the receiver **520** and will store a service group turn-on offset value received from the receiver **520** in the stored turn-on offset register **970** included in this example alternative embodiment of a logic controller **525**. Accordingly, the state machine will select a service group turn-on offset value from information received from the receiver **520** according to the identifier **901**, which in this example embodiment comprises a service group identifier.

In one alternative example embodiment, the state machine **900** is configured to receive a turn-off offset value including at least one of a geographic-region turn-off offset and a service group turn-off offset. According to this alternative example embodiment, the state machine **900** determines the type of turn-off offset that should be used based on the "use geographic-region turn-off offset" mode indicator **915** and the "use service group turn-off offset" mode indicator **925**. When the "use geographic-region turn-off offset" mode indicator **915** is set, state machine **900** will ignore service group turn-off offset values that are received from the receiver **520** and will store a geographic-region turn-off offset value received from the receiver **520** in a stored turn-off offset register **980** included in this example alternative embodiment of a logic controller **525**. It should be appreciated that the state machine will select a geographic-region turn-off offset value from information received by the receiver **520** and selecting a geographic-region turn-off offset value according to the identifier **901**, which in this example embodiment comprises a geographic region identifier. When the "use service group turn-off offset" mode indicator **925** is set, state machine **900** will ignore geographic-region turn-off offset values that are received from the receiver **520** and will store a service group turn-off offset value received from the receiver **520** in the stored turn-off offset register **980** included in this example alternative embodiment of a logic controller **525**. Accordingly, the state machine will select a service group turn-off offset value from information received from the receiver **520** according to the identifier **901**, which in this example embodiment comprises a service group identifier.

FIG. **21** also illustrates that according to one alternative example embodiment, the logic controller **525** receives a dimming profile including at least one of a geographic-region dimming profile, a service group dimming profile, and a prestored dimming profile. It should be appreciated that these dimming profiles are typically, but not necessarily received by means of the receiver **520**. As the state machine **900** continues to operate, it determines the type of dimming profile that should be received based on the geographic region dimming profile mode indicator **940**, the use service group dimming profile mode indicator **945** and the use stored dimming profile **950**. In the case where the geographic-region dimming profile mode indicator **940** is set, state machine **900** will receive, by means of the receiver **520**, a dimming profile for a geographic-region selected from information received by their receiver **520** according to the identifier **901**. Once the dimming profile for a geographic-region is extracted from information received by the receiver **520**, that dimming profile is stored in a received dimming profile table **985**. In the case where the state machine **900**, as a continues to operate, determines that the use service group dimming profile mode indicator **945** is set, then the state machine **900** will receive information from the receiver **520** and will extract a dimming profile for a particular service group and store that dimming profile in the received dimming profile table **985**. In the event that the prestored dimming profile mode indicator **950** is set, the state machine **900** will receive a dimming profile and store the dimming profile in the prestored dimming profile table **990**. This dimming profile, according to this example alternative embodiment, will remain as a static dimming profile and will continue to be stored in the pestored dimming profile table **990**. It should be appreciated that, according to this illustrative example embodiment, a dimming profile table **1061** comprises at least two columns of information including, but not limited to at least one of a time value **1060** and a level value **1065**. It should be appreciated that state machine **900** stores the dimming profile in the dimming profile table **1061** according to time values and level values which are then associated with particular time values.

FIG. **21** further illustrates that according to yet another alternative example embodiment, a luminary controller **510** also includes an override receiver **521**. According to this alternative example embodiment, the override receiver **521** comprises a receiver receiving information on a different radio frequency than directives and other information received by receiver **520**. It should be appreciated that, according to this illustrative example embodiment, the override receiver **521** is used to receive static information including, but not limited to at least one of a prestored turn on offset (which is stored in the stored turn on offset register **965**), a prestored turn off offset (which is stored in the stored turn off offset register **975** and prestored dimming profile which is stored in a prestored dimming profile table **990**. In yet another alternative example embodiment, the override receiver **521** receives override directives as defined supra and directs these override directives to state machine **900**. In all cases, the state machine **900** is responsive to information received from the override receiver **521** in a manner analogous to the state machine's **900** operation as it receives information from the first information receiver **520**.

FIG. **21** also illustrates that according to yet another alternative example embodiment, a luminary controller **510** includes a logic controller **525** wherein the state machine **900** is responsive to one or more input signals, which are derived by comparing a current time **1050** to at least one of a determined turn on time and a determined turn off time. In one example alternative embodiment, a standard turn on time stored in a turn on time register **955** is compared to a current time value **1050**. In this case, the state machine **900**, upona successful comparison, generates a command to the power controller **530** in order to turn on the luminary. In yet another alternative example embodiment, standard turn on time, also stored in a turn on time register **955**, is added to (**1000**) either to a prestored turn-on offset, which is stored in a turn on offset register **965**, or is added to a received turn on offset which is stored in a received turn on offset register **970**. The state machine **900** uses either the prestored turn on offset **965** or the received turn on offset **970** based on the state of the use prestored turn on offset mode indicator **930**. When the prestored turn on offset mode indicator **930** is set, then the value stored in the stored prestored turn on offset register **965** is used. Otherwise the value stored in the received turn on offset register **970** is used as an offset to standard turn on time stored in the standard turn on time register **955**. In this alternative example embodiment, the stored or the received turn on offset is added (**1000**) to the standard turn on time value stored in a register **955** and is then compared to the current time **1050**. According to various alternative example embodiment, the comparison of either of the standard turn on time value stored in register **955** (standard turn on time register) or the sum of the standard turn on time value a selected the turn on offset is accomplished by at least one of an equal to comparator **1021**, an equal to or greater than comparator **1020**, and a greater than comparator **1015**. The output of these comparators is sampled by the state machine **900**. According to various alternative example embodiments, the state machine **900** responds to one of at least an active signal (**1041**) from either the equal to comparator **1021**, an active signal (**1040**) the greater than or equal to comparator **1020** and an active signal **1035** from the greater than comparator **1015**. In response to one or more of these active signals, the state machine **900** direct state command to the power controller **530** in order to activate power to the luminary.

In one example alternative embodiment, a standard turn off time stored in a turn off time register **960** is compared to a current time value **1050**. In this case, the state machine **900**, upon a successful comparison, generates a command to the power controller **530** in order to turn off the luminary. In yet another alternative example embodiment, the standard turn off time, also stored in a turn off time register **960**, is added to (**995**) either to a prestored turn-off offset, which is stored in a prestored turn off offset register **975**, or is added to a received turn off offset which is stored in a received turn off offset register **980**. The state machine **900** uses either the prestored turn off offset **975** or the received turn off offset **980** based on the state of the use prestored turn off offset mode indicator **935**. When the prestored turn off offset mode indicator **935** is set, then the value stored in the prestored turn off offset register **975** is used. Otherwise the value stored in the received turn off offset register **980** is used as an offset to standard turn off time stored in the standard turn off time register **960**. In this alternative example embodiment, the stored or the received turn off offset is added (**995**) to standard turn off time value stored in a register **960** and is then compared to the current time **1050**. According to various alternative example embodiment, the comparison of either of the standard turn off time value stored in register **960** (standard turn off time register) or the sum of the standard turn off time value and one of the selected turn off offsets is accomplished by at least one of an equal to comparator **1006**, an equal to or greater than compartor **1005**, and a greater than compartor **1010**. The output of these comparators is sampled by the state machine **900**. According to various alternative example embodiment, the state machine **900** responds to one of at least an active signal (**1007**) from either the equal to comparator **1006**, an active signal (**1025**) the greater than or equal to comparator **1005** and an active signal **1030** from the greater then comparator **1010**. In response to one or more of these active signals, the state machine **900** directs a command to the power controller **530** in order to turn off power to the luminary.

In one example alternative embodiment, the state machine **900** uses as the basis for dimming. i.e. reducing the power provided to, the luminary at least one of a prestored dimming profile that is stored in the stored dimming profile table **990** included in this alternative embodiment of a logic controller **525** and a received dimming profile stored in the received dimming profile table **985** included in this alternative example embodiment. As the state machine **900** continues to operate, it will receive a dimming control signal **906** from the clock **905**. When the state machine **900** receives the dimming control signal **906**, the state machine **900** will respond by obtaining a dimming level from at least one of the stored dimming profile table **990** and the received dimming profile table **985**. The state machine **900** will select one of the dimming profile tables based on the use stored dimming profile mode indicator **950**. In the event that the use stored dimming profile monitor **950** is set, then the state machine will use the prestored dimming profile table **990** as the basis for reducing power to the luminary **500**. Otherwise, the state machine **900** will use the received dimming profile table **985** as the basis for reducing power to the luminary **500**. Whenever the state machine **900** receives a dimming control signal **906** from the clock **905**, the state machine will retrieve from the selected the dimming profile table (i.e. either the received dimming profile table **985** of the prestored dimming profile table **990**) a level value (as depicted in the example table as column **1065**), said value being selected according to a time value (as depicted in the example table column **1060**) and said selection time value (**1050**) being provided by the clock **905**. Once the state machine **900** receives the dimming level value from at least one of the stored dimming profile table **990** and the received dimming profile table **985**, the state machine **900** generates a level command to the power controller **530**, said level command comprising, according to one alternative example embodiment, a duty cycle value.

FIG. **22** is a block diagram that depicts alternative example embodiments of a luminary controller. In one example embodiment, a luminary controller **510** comprises one or more processors **1100**, a memory **1115**, a main receiver **1105**, and a power controller **1120**. In one alternative embodiment, a luminary controller **510** further comprises an override receiver **1110**. It should be appreciated that the receiver **1105** and in those embodiments that further included the override receiver **1110**, according to various alternative example embodiments, comprise at least one of a wired network interface and a wireless receiver including, but not limited to a short-range remote control receiver, a long-range information receiver, and infrared communication link and a wireless network receiver. Accordingly, in those embodiments where the receiver (**1105** or **1110**) comprises a wireless receiver, an antenna **1107** is also included in the luminary controller **510**. It should further be recognized that the antenna **1107**, according to alternative illustrative embodiments, is disposed either within the luminar controller **510** or is disposed external there to. In those alternative example embodiments where the receiver comprises a network interface, such a network interface comprises at least one of a wired and wireless network interface. In either case, connectivity to a network enables the processor **1100** to receive information and operating directives according to the methods taught herein. It should also be appreciated that, according to various alternative example embodiments, a luminary controller **510** further comprises a clock **1102** and a power controller **1120**. The power controller **1120** receives AC input power **1125** and delivers the AC input power to a reactive load **1130**, e.g. a magnetic ballast which in turn drives an arc discharge lamp **1130**. It should further be appreciated that the reactive load returns AC back to the source **1135**.

Also included in various example alternative embodiments of aluminary controller **510** are one or more functional modules. A functional module is typically embodied as an instruction sequence. An instruction sequence that implements a functional module, according to one alternative embodiment, is stored in the memory **1115**. The reader is advised that the term "minimally causes the processor" and variants thereof is intended to serve as an open-ended enumeration of functions performed by the processor **1100** as it executes a particular functional module (i.e. instruction sequence). As such, an embodiment where a particular functional module causes the processor **1100** to perform functions in addition to those defined in the appended claims is to be included in the scope of the claims appended hereto.

The functional modules (i.e. their corresponding instruction sequences) described thus far that enable luminary control according to the present method are, according to one alternative embodiment, imparted onto computer readable medium. Examples of such medium include, but are not limited to, random access memory, read-only memory (ROM), programmable read only memory, flash memory, electrically erasable programmable read only memory, compact disk ROM (CD ROM), floppy disks, hard disk drives, magnetic tape and digital versatile disks (DVD). Such computer readable medium, which alone or in combination can constitute a stand-alone product and can be used to convert a general-purpose computing platform into a device capable of controlling luminaries according to the techniques and teachings presented herein. Accordingly, the claims appended hereto are to include such computer readable medium imparted with such instruction sequences that enable execution of the present method and all of the teachings herein described.

FIG. **22** further illustrates that, according to one alternative example embodiment, a luminary controller **510** includes a message parser module **1140**, the mode Manager module **1145**, and a level module **1180**, all of which are stored in the memory **1115**. According to this alternative example embodiment, the luminary controller **510** further includes an identifier **1245**, which is stored in the memory **1115**. In one example embodiment, the luminary controller **510** further includes mode indicators stored in memory **1115** including but not limited to a geographic-region turn on offset mode indicator **1150**, and a geographic-region turnoffs offset mode indicator **1155**. In yet another alternative example embodiment, the luminary controller **510** further includes at least one of a service group turn on offset mode indicator **1160** and a service group turn off the offset mode indicator **1165**, any one or more of which are stored in the memory **1115**. And in yet another alternative example embodiment, the luminary controller **510** further includes at least one of a prestored turn on offset mode indicator **1170** and a prestored turnoffs offset mode indicator **1175**, any one or more of which are stored in the memory **1115**. In one alternative example embodiment, the luminary controller **510** further includes dimming mode indicators stored in the memory **1115**, said dimming mode indicators including at least one of a geographic-region at dimming mode indicator **1185**, a service group dimming mode indicator **1190** and a prestored dimming mode indicator **1200**.

FIG. **22** also illustrates that, according to various alternative example embodiments, various operating information is stored in the memory **1115**. In one alternative example embodiment, the memory **1115** is used to store at least one of a standard turn on time **1205** and a standard turn off time **1210**. In yet another alternative example embodiment, the memory **1115** is used to store at least one of a prestored turn on offset **1215** and a prestored turnoffs offset **1220**. And in yet another alternative example embodiment, the memory **1115** is used to store at least he received turn on offset **1225** and a received turn off offset **1230**. In yet another example alternative embodiment, the memory **1115** is used to receive at least one of a received dimming profile **1235** and a prestored dimming profile **1240**.

FIG. **23** is a data flow diagram that depicts the operation of a processor-based luminary controller. As the processor **1100** begins to execute instructions, the processor **1100** begins executing instructions included in the message parser **1140**. It should be appreciated that, according to one preferred alternative embodiment, particular forms of information are received either from the main receiver **1105** or the override receiver **1110**. However, the claims appended hereto are not intended to be limited in scope to any one preferred alternative embodiment and the scope of the claims appended hereto is to embrace embodiments where information is received from either receiver for any particular purpose. For example, the preponderance of information necessary to control the luminary is received **1250** from the main receiver **1105** whereas override directives are typically received from the override receiver **1110**. Again, the claims appended hereto are not to be limited in scope and in fact information necessary to control the luminaries, according to alternative embodiments, are received by means of the override receiver **1110** and override directives are received by the main receiver **1105**.

The message parser **1140**, when executed by the processor **1100**, minimally causes the processor **1100** to receive information from at least one of the main receiver **1105** and the override receiver **1110**. As messages are received by the processor **1100**, as it executes the message parser module **1140**, the processor **1100** recognizes particular types of messages including, but not limited to information messages and operating directives. Upon startup, the message parser module **1140**, when executed by the processor **1100**, minimally causes the processor **1100** to determine a data source from which the main receiver **1105** will receive information. As the processor **1100** continues to execute the message parser **1140**, the message parser **1140** minimally causes the processor **1100** to set the main receiver **1105** to a particular radio frequency. The processor **1100** will then search for a perceptible datastream at that particular radio frequency. In the event that a perceptible datastream is not present a particular radio frequency, the processor **1100**, as it continues to execute the message parser **1140**, will direct the main receiver **1105** to receive at a different frequency. This process continues until the processor **1100** detects a perceptible datastream on a radio frequency received by the main receiver **1105**. At this stage, the processor **1100**, according to one alternative example embodiment, will receive a list of service groups from the main receiver **1105**. The processor **1100**, as it continues to execute this example embodiment of a message parser **1140**, conducts a comparison of an identifier value **1245** to various identifiers included in a received list of service groups. In the event that a successful comparison is achieved, the processor **1100**, as it continues to execute this example embodiment of a message parser module **1140**, the processor **1100** continues to use the radio frequency to which the main receiver **1105** was previously directed to by the processor **1100** as it executed this example embodiment of a message parser module **1140**. This radio frequency is said to be associated with "an identified data source". In the event that a successful comparison is not achieved, the processor **1100** will direct the main receiver **1105** two a different radio frequency and continue the process until the processor **1100** receives a list of service groups that includes an identifier which is substantially equivalent to the identifier **1245** stored in the memory **1115**.

In one alternative embodiment, the message processor **1140**, when executed by the processor **1100**, minimally causes the processor **1100** to recognize a time beacon message, which is received either from the main receiver **1105** or the override receiver **1110**. Again, the source of the information is not necessarily relevant from the perspective of the processor **1100** as it executes the message parser module **1140**. In response to a time beacon message, the processor **1100**, as it continues to further execute the message parser **1140**, extracts a time value from the time beacon message and stores the time value into the clock **1102**.

As the processor **1100** continues to execute the message parser **1140**, the processor **1100** receives (**1250**, **1255**) other forms of information and operating directives. In one alternative example embodiment, the message parser **1140**, when executed by the processor **1100**, further minimally causes the processor **1100** to recognize including at least one of a geographic-region turn on offset mode directive and a geographic-region turn off offset mode directive. When receiving such operating mode directives, the processor **1100** executes the mode manager **1145**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a geographic-region turn on offset mode indicator **1150** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a geographic-region turn on offset mode directive from the message parser **1140**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a geographic-region turn off offset mode indicator **1155** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a geographic-region turn off offset mode directive from the message parser **1140**.

In yet another example embodiment, the processor **1100**, extracts from at least one of a geographic-region turn on offset mode directive and a geographic-region turn off offset mode directive a geographic region type identifier. For example, various types of geographic-regions may be identified in information received from an identified data source. In one example embodiment, the processor **1100** extracts a climate-region type identifier from at least one of a geographic-region turn on offset mode directive and a geographic-region turn off offset mode directive. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a geographic-region type identifier from a geographic-region turn on offset mode directive; the processor **1100** stores the extracted geographic-region type identifier in the geographic region turn on offset mode indicator **1150**, which is stored in the memory **1115**. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a geographic-region type identifier from a geographic-region turn off offset mode directive, the processor **1100** stores the extracted geographic-region type identifier in the geographic region turn off offset mode indicator **1150**, which is stored in memory **1115**. According to one illustrative use case, a geographic-region type identifier may refer to a geographic-region comprising a micro-climate region as discussed supra.

In one alternative example embodiment, the message parser **1140**, as it is executed by the processor **1100**, further minimally causes the processor **1100** to recognize least one of a service group turn on offset mode directive and a service group turn off offset mode directive. When receiving such operating mode directives, the processor **1100** executes the mode manager **1145**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a service group turn on offset mode indicator **1160** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a service group turn on offset mode directive from the message parser **1140**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a service group turn off offset mode indicator **1165** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a service group turn off offset mode directive from the message parser **1140**.

In yet another example embodiment, the processor **1100**, extracts from at least one of a service group turn on offset mode directive and a service group turn off offset mode directive a service group type identifier. For example, various types of service groups may be identified in information received from an identified data source. In one example embodiment; the processor **1100** extracts a service group type identifier that corresponds to at least one of a municipal entity, a government entity, a private operator, and a specific luminary group from at least one of a service group turn on offset mode directive and a service group turn off offset mode directive. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a service group type identifier from a service group turn on offset mode directive, the processor **1100** stores the extracted service group type identifier in the service group region turn on offset mode indicator **1160**, which is stored in the memory **1115**. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a service group type identifier from a service group turn off offset mode directive, the processor **1100** stores the extracted service group type identifier in the service group turn off offset mode indicator **1165**, which is stored in memory **1115**.

In one alternative example embodiment, the message parser **1140**, when executed by the processor **1100**, further minimally causes the processor **1100** to recognize least one of a use prestored turn on offset mode directive and a use prestored turn off offset mode directive. When receiving such operating mode directives, the processor **1100** executes the mode manager **1145**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a use prestored turn on offset mode indicator **1170** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a use prestored turn on offset mode directive from the message parser **1140**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a use prestored turn off offset mode indicator **1175** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a use prestored turn off offset mode directive from the message parser **1140**.

In one alternative example embodiment, the message parser **1140**, when executed by the processor **1100**, further minimally causes the processor **1100** to recognize least one of a use service group dimming mode directive, a use geographic-region dimming mode directive and a use prestored dimming mode. When receiving such operating mode directives, the processor **1100** executes the mode manager **1145**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a use service group dimming mode indicator **1190** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a use service group dimming mode directive from the message parser **1140**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a use geographic-region dimming mode indicator **1185** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a use geographic-region dimming offset mode directive from the message parser **1140**. The mode manager **1145**, as it is executed by the processor **1100**, minimally causes the processor to set a use prestored dimming mode indicator **1200** stored in the memory **1115** when the mode manager **1145** is executed by the processor **1100** and receives **1260** a use prestored dimming mode directive from the message parser **1140**.

In one example embodiment, the processor **1100** extracts a geographic-region type identifier that corresponds to a particular type of geographic-region, e.g. a micro-climate region. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a geographic-region type identifier from a dimming mode directive, the processor **1100** stores the extracted geographic-region type identifier in the geographic-region dimming mode indicator **1185**, which is stored in the memory **1115**.

In one example embodiment, the processor **1100** extracts a service group type identifier that corresponds to at least one of a municipal entity, a government entity, a private operator, and a specific luminary group from dimming mode directive. In the case where the processor **1100**, as it executes the mode manager **1145**, extracts a service group type identifier from a dimming mode directive, the processor **1100** stores the extracted service group type identifier in the service group dimming mode indicator **1190**, which is stored in the memory **1115**.

As the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor to receive operational information from at least one of the main receiver **1105** and the override receiver **1110**. In some cases, the main receiver **1105** is used to receive information that changes on a periodic basis. For example, the main receiver **1105** is typically used to receive information such as a standard turn on time and a standard turn off time. Again this is merely an example embodiment and the claims appended hereto are not intended to be limited in scope with respect to which receiver is used to receive any particular type of information or operational director. For example, standard turn on time and standard turn off time may just as easily be received by means of the override receiver **1110**. According to this example embodiment, the message parser **1140**, as it is executed by the processor **1100**, minimally causes the processor to respond to a standard turn on time message by extracting a standard turn on time value and storing it in a standard turn on time variable **1205**, which is stored in the memory **1115**. According to yet another example embodiment, the message parser **1140**, as it is executed by the processor **1100** minimally causes the processor to respond to a standard turnoff time message by extracting a standard turnoff time value from the message and storing it in a standard turnoff time variable **1210**, which is stored in the memory **1115**. According to one illustrative use case, a standard turn on time comprises the time of sunset. In yet another illustrative use case, standard turnoff time comprises the time of sunrise.

According to one alternative example embodiment, the message parser **1140**, as it is executed by the processor **1100**, further minimally causes the processor **1100** to recognize various turn on offset and turn off offset messages. For example, in one alternative illustrative embodiment, the message parser **1140** further minimally causes the processor **1100** to recognize at least one of a geographic-region turn on offset message, a service group turn on offset message, and a prestored turn on offset message. Typically, but not necessarily, the geographic-region turn on offset message and the service group turn on offset message are received by means of the main receiver **1105**. Again, in one illustrative application, a geographic-region turn on offset message and a service group turn on offset message typically include offset values that vary over time (e.g. for example on a daily, weekly or monthly basis). Typically, but not necessarily, the prestored turn on offset message includes a turn on offset that is relatively static. Typically such static information is received by means of the override receiver **1110** and such static information is received at a convenient time prior, to contemporaneous with, or after installation of the luminary controller **510** on a luminary fixture **500**.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular turn on offset message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn on offset message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** when the use geographic-region turn on offset mode indicator **1150** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn on offset message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** and also based on a type of the geographic-region turn on offset message according to a geographic-region type indicator stored in the geographic-region turn on offset mode indicator **1150**. In each particular case, the geographic-region identifier **1245** stored in the memory **1115** refers to at least one of a specific geographic region and to a specific geographic region/geographic region type. Once a turn on offset message for a particular geographic-region is selected, a turn on offset value is extracted from the message and stored in the received turn on offset variable **1225** stored in the memory **1115**.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular turn off offset message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn off offset message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** when the use geographic-region turn off offset mode indicator **1155** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn off offset message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** and also based on a type of the geographic-region turn off offset message according to a geographic-region type indicator stored in the geographic-region turn off offset mode indicator **1155**. In each particular case, the geographic-region identifier **1245** stored in the memory **1115** refers to at least one of a specific geographic region and to a specific geographic region/geographic region type. Once a turn off offset message for a particular geographic-region is selected, a turn off offset value is extracted from the message and stored in the received turn on offset variable **1230** stored in the memory **1115**.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular turn on offset message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn on offset message for a particular service group based on the identifier **1245** that is stored in the memory **1115** when the use service group turn on offset mode indicator **1160** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn on offset message for a particular service group based on the identifier **1245** that is stored in the memory **1115** and also based on a type of the service group turn on offset message according to a service group type indicator stored in the service group turn on offset mode indicator **1160**. In each particular case, the service group identifier **1245** stored in the memory **1115** refers to at least one of a specific service group and to a specific service group/service group type. Once a turn on offset message for a particular service group is selected, a turn on offset value is extracted from the message and stored in the received turn on offset variable **1230** stored in the memory **1115**.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular turn off offset message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn off offset message for a particular service group based on the identifier **1245** that is stored in the memory **1115** when the use service group turn off offset mode indicator **1165** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select a turn off offset message for a particular service group based on the identifier **1245** that is stored in the memory **1115** and also based on a type of the service group turn off offset message according to a service group type indicator stored in the service group turn off offset mode indicator **1165**. In each particular case, the service group identifier **1245** stored in the memory **1115** refers to at least one of a specific service group and to a specific service group/service group type. Once a turn off offset message for a particular service group is selected, a turn off offset value is extracted from the message and stored in the received turn off offset variable **1230** stored in the memory **1115**.

According to one alternative example embodiment, the message parser **1140**, as it is executed by the processor **1100**, further minimally causes the processor **1100** to recognize various dimming profile messages. For example, in one alternative illustrative embodiment, the message parser **1140** further minimally causes the processor **1100** to recognize at least one of a geographic-region dimming profile message, a service group dimming profile message, and a prestored dimming profile message.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor **1100** to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular dimming profile message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select dimming profile message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** when the use geographic-region dimming mode indicator **1185** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select dimming profile message for a particular geographic-region based on the identifier **1245** that is stored in the memory **1115** and also based on a type of the geographic-region that a particular message pertains to according to a geographic-region type indicator stored in the geographic-region dimming mode indicator **1185**. In each particular case, the geographic-region identifier **1245** stored in the memory **1115** refers to at least one of a specific geographic region and to a specific geographic region/geographic region type. Once a dimming profile message for a particular geographic-region is selected, a dimming profile table is extracted from the message and stored in the received dimming profile variable **1235** stored in the memory **1115**.

According to one alternative example embodiment, the processor **1100** continues to execute the message parser **1140**, the message parser **1140** further minimally causes the processor **1100** to discriminate messages received by means of at least one of the main receiver **1105** and the override receiver **1110** in order to select a particular dimming profile message from information transmitted from an identified data source. According to one example embodiment, the message parser **1140** minimally causes the processor **1100** to select dimming profile message for a particular service group based on the identifier **1245** that is stored in the memory **1115** when the use service group dimming mode indicator **1190** is set. In yet another alternative example embodiment, the message parser **1140** minimally causes the processor **1100** to select dimming profile message for a particular service group based on the identifier **1245** that is stored in the memory **1115**, and also based on a type of the service group that a particular message pertains to according to a service group type indicator stored in the service group dimming mode indicator **1190**. In each particular case, the service group identifier **1245** stored in the memory **1115** refers to at least one of a specific service group and to a specific service group/service group type. Once a dimming profile message for a particular service group is selected, a dimming profile table is extracted from the message and stored in the received dimming profile variable **1235** stored in the memory **1115**.

According to one example illustrative embodiment, the processor **1100**, as it continues to operate, executes the level module **1180**, which is stored in the memory **1115**. As the processor **1100** executes the level module **1180**, the level module **1180** minimally causes the processor to receive a time value from the clock **1102**. The level module **1180** causes the processor to receive a time value on a periodic basis. Typically, but not necessarily, the level module **1180** is executed by the processor as an interrupt service routine in response to a clock pulse provided by the clock **1102**.

This illustrative embodiment, the level module **1180** further minimally causes the processor **1100** to compare a time value received from the clock **1102** to at least one of a standard turn on time value (stored in the memory **1115** in a standard turn on time variable **1205**) and a standard turn off time value (stored in the memory of **1115** and a standard turn off time variable **1210**).

In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to the standard turn on time value (**1205**), the processor **1100** conveys **1285** a turn on command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to or greater than the standard turn on time value (**1205**), the processor **1100** conveys **1285** a turn on command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is greater than the standard turn on time value (**1205**), the processor **1100** conveys **1285** a turn on command to the power controller **1120**.

According to yet another alternative example embodiment, the level module **1180**, as it is executed by the processor **1100**, further minimally causes the processor **1100** to retrieve at least one of a geographic-region turn on offset mode indicator **1150**, a service group turn on offset mode indicator **1160** and a pre-stored turn on offset mode indicator **1170** from the memory **1115**. When at least one of the geographic-region turn on offset mode indicator **1150**, the service group turn on offset mode indicator **1160** and the pre-stored turn on offset mode indicator **1170** are true (e.g. are set or are used to store an type of geographic region or service group type), then the processor **1100**, as it continues to execute the level module **1180**, retrieves the standard turn on time **1205** from the memory **1115** and at least one of a received turn on offset **1225** and a prestored turn on offset **1215**. The processor **1100** is further minimally caused to add the standard turn on time **1205** to either of the received turn on offset **1225** or the prestored turn on offset **1215** based on the state of the prestored turn on offset mode indicator **1170**. It should be appreciated that the prestored turn on offset **1215** is used when the prestored turn on offset mode indicator **1170** is true. The resulting sum is referred to as the determined turn on time.

In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to the determined turn on time, the processor **1100** conveys **1285** a turn on command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to or greater than the determined turn on time, the processor **1100** conveys **1285** a turn on command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is greater than the determined turn on time, the processor **1100** conveys **1285** a turn on command to the power controller **1120**.

In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to the standard turn off time value (**1210**), the processor **1100** conveys **1285** a turn off command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to or greater than the standard turn off time value (**1210**), the processor **1100** conveys **1285** a turn off command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is greater than the standard turn off time value (**1210**), the processor **1100** conveys **1285** a turn on command to the power controller **1120**.

According to yet another alternative example embodiment, the level module **1180**, as it is executed by the processor **1100**, further minimally causes the processor **1100** to retrieve at least one of a geographic-region turn off offset mode indicator **1155**, a service group turn off offset mode indicator **1165** and a pre-stored turn off offset mode indicator **1175** from the memory **1115**. When at least one of the geographic-region turn off offset mode indicator **1155**, the service group turn off offset mode indicator **1165** and the pre-stored turn off offset mode indicator **1175** are true (e.g. are set or are used to store an type of geographic region or service group type), then the processor **1100**, as it continues to execute the level module **1180**, retrieves the standard turn off time **1210** from the memory **1115** and at least one of a received turn off offset **1230** and a prestored turn off offset **1220**. The processor **1100** is further minimally caused to add the standard turn off time **1210** to either of the received turn off offset **1230** or the prestored turn off offset **1220** based on the state of the pre-stored turn off offset mode indicator **1175**. It should be appreciated that the prestored turn off offset **1220** is used when the prestored turn off offset mode indicator **1175** is true. The resulting sum is referred to as the determined turn off time.

In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to the determined turn off time, the processor **1100** conveys **1285** a turn off command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is equal to or greater than the determined turn off time, the processor **1100** conveys **1285** a turn off command to the power controller **1120**. In one alternative example embodiment, when the processor **1100**, as it continues to execute the level module **1180**, determines that the time value received from the clock **1102** is greater than the determined turn off time, the processor **1100** conveys **1285** a turn off command to the power controller **1120**.

In yet another alternative example embodiment, the processor **1100**, as it continues to execute the level control module **1180**, determines if a dimming profile is to be utilized in controlling the luminary based on the state of dimming mode indicators including at least one of a geographic-region dimming mode indicator **1185**, a service group dimming mode indicator **1190**, and a prestored dimming mode indicator **1200**. If any of these dimming mode indicators is true, then a dimming profile is retrieved from memory. In this alternative example embodiment, the processor **1100** retrieves at least one of a received dimming profile **1235** and a prestored dimming profile **1240** from the memory **1115**. According to this alternative example embodiment, the processor **1100**, as it continues to execute the level module **1180**, determines which dimming profile to retrieve from memory based on the state of the prestored dimming mode indicator **1200**. In the event that the prestored dimming mode indicator **1200** is true, and the processor **1100**, as it continues to execute the level module **1180**, will retrieve the prestored dimming profile **1240** from the memory **1115**. Otherwise, the processor **1100** will retrieve the received dimming profile **1235** from the memory **1115**.

As the processor **1100** continues to execute the level module **1180**, it will receive a time value from the clock **1102**. The processor **1100** looks to the dimming profile retrieved from the memory **1115**. As already described in FIG. **21**, a dimming profile includes a time interval field **1060** and a level indicator field **1065**. The processor **1100** identifies a record within the dimming profile according to the time value received from the clock **1102** and various time interval definitions stored in the time interval field **1060**. When the processor **1100**, as it continues to execute the level module **1180**, identifies a record within the dimming profile wherein the time interval field **1060** is substantially consistent with the current time value received from the clock **1102**, then the processor **1100** retrieves a level indicator from the level field **1065** of the identified record included in the dimming profile retrieved from the memory **1115**. Accordingly, the processor **1100** then conveys **1285** a dimming level to the power controller **1120**. It should be appreciated that the power controller **1120** comprises according to this alternative example embodiment, a synchronous buck down-converter commensurate with the teachings herein.

In yet another alternative example embodiment, the message parser **1140**, as it is executed by the processor **1100**, further minimally causes the processor to recognize particular override commands including, but not limited to at least one of a turn on command, a turn off command, and a dim command. Typically, but not necessarily, such override commands are received by means of the override receiver **1110**. However in alternative embodiments, override commands are received by the Main receiver **1105**. Such override commands are useful in case of exigent circumstances such as law enforcement activities where a dim and luminary needs to be elevated to full power or where a luminary needs to be extinguished in order to cloak law enforcement activities. A dim override command is useful in brownout situations when the load on the power grid needs to be reduced.

When the processor **1100**, as a result of its continued execution of one alternative example embodiment of a message parser **1140**, recognizes a turn on command, the processor **1100** conveys **1265** a turn on command to the level module **1180**. In turn, the level module **1180** when executed by the processor **1100** conveys a turn on message to the power controller **1120**. This results in application of full power to the luminary lighting element **1130**. When the processor **1100**, as a result of its continued execution of one alternative example embodiment of a message parser **1140**, recognizes a turn off command, the processor **1100** conveys **265** he turn off command to the level module **1180**. In turn, the level module **1180**, when executed by the processor **1100**, conveys a turn off message to the power controller **1120**. This results in depriving the luminary lighting element **1130** of electrical power. In yet another alternative example embodiment of a message parser **1140**, the processor **1100**, as it continues to execute this alternative example embodiment of a message parser **1140**, recognizes a dim command. When the processor **1100** recognizes a dim command, the processor **1100** directs the level module **1180** to reduce the amount of power applied to the luminary lighting element **1130**. As a result, the level module **1180** will convey **1285** a light level command to the power controller **1120** commensurate with the recognized dim command.

While the present method and apparatus has been described in terms of several alternative and exemplary embodiments, it is contemplated that alternatives, modifications, permutations, and equivalents thereof will become apparent to those skilled in the art upon a reading of the specification and study of the drawings. It is therefore intended that the true spirit and scope of the claims appended hereto include all such alternatives, modifications, permutations, and equivalents.

What is claimed is:

1. An apparatus for reducing the amplitude of voltage provided by an alternating current power source comprising:

an input terminal for receiving an alternating current from a power source;

a common terminal for receiving an alternating current from at least one of a neutral conductor and a return current from a load;

a bi-directional buck switch comprising a first port for receiving the alternating current received by means of the input terminal and a second port for distributing the alternating current when the bi-directional buck switch is on;

a bi-directional freewheel switch comprising a first port for receiving the alternating current received by means of the common terminal and a second port for distributing the alternating current when the bi-directional freewheel switch is on;

a buck inductor comprising a first port for receiving the alternating current distributed by at least one of the bi-directional buck switch and the bi-directional freewheel switch said buck inductor further comprising a second port for distributing the alternating current received by the first port of said inductor;

an output terminal for conveying the alternating current distributed by the inductor to the load;

a current sensor disposed so as to generate a direction signal according to the direction of current flow in the inductor; and

a power controller for controlling in a complimentary manner according to a duty factor and according to the direction signal the bi-directional buck switch and the bi-directional freewheel switch by

partially disabling the freewheel switch so as to allow current flow substantially in one direction then waiting a period of time and then

partially enabling the buck switch so as to allow current flow substantially in one direction then waiting a period of time and then

disabling the freewheel switch so as to substantially prevent the flow of current through said freewheel switch then waiting a period of time and then enabling the buck switch so as to substantially allow current to flow in both directions.

2. The apparatus of claim 1 further comprising:

a three blade plug for interfacing the input terminal, the output terminal, and the neutral terminal to a luminary fixture.

3. The apparatus of claim 2 further comprising a receiver for receiving a duty factor and a dimming controller that conveys the duty factor to the power controller.

4. The apparatus of claim 3 wherein the dimming controller comprises a state machine.

5. The apparatus of claim 3 wherein the dimming controller comprises:

processor;

memory for storing instruction sequences and information; and

instruction sequences stored in the memory including:

a message parser that, when executed by the processor, minimally causes the processor to receive the duty factor from the receiver; and

a dimming module that conveys the duty factor to the power controller.

6. A system for dimming luminaries comprising:

a transmitter for broadcasting dimming information;

a three terminal luminary dimmer unit comprising:

an input terminal for receiving an alternating current from a power source;

a common terminal for receiving an alternating current from at least one of a neutral conductor and a return current from a load;

a bi-directional buck switch comprising a first port for receiving the alternating current received by means of the input terminal and a second port for distributing the alternating current when the bi-directional buck switch is on;

a bi-directional freewheel switch comprising a first port for receiving the alternating current received by means of the common terminal and a second port for distributing the alternating current when the bi-directional freewheel switch is on;

a buck inductor comprising a first port for receiving the alternating current distributed by at least one of the bi-directional buck switch and the bi-directional freewheel switch said buck inductor further comprising a second port for distributing alternating current received by the first port of said inductor;

an output terminal for conveying the alternating current distributed by the inductor to a load; and

a current sensor disposed so as to generate a direction signal according to the direction of current flow in the inductor;

a power controller for controlling in a complimentary manner according to a duty factor and according to the direction signal the bi-directional buck switch and the bi-directional freewheel switch by

partially disabling the freewheel switch so as to allow current flow substantially in one direction then waiting a period of time and then

partially enabling the buck switch so as to allow current flow substantially in one direction then waiting a period of time and then disabling the freewheel switch so as to substantially prevent the flow of current through said freewheel switch then waiting a period of time and

then enabling the buck switch so as to substantially allow current to flow in both directions.

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